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A Report to the Society by the President

ROBERT E. DOHERTY

Things move fast now! A report becomes out of date while it is being published. However, I shall report on the principal problems facing engineering education as they appear on April 15, 1944, and on what the Society is doing about them. Topics included are the A.S.T.P., Selective Service deferments, education for returning veterans, universal military service, Surplus Property as a possible source of apparatus for engineering colleges, training of foreign students in engineering, and the work of the Committee on Engineering Education After the War.

The recent drastic actions of A.S.T.D. and Selective Service spring from the same cause. As indicated in my report last month, the remnants of young manpower are now insufficient to meet the imperative demands of the armed forces *for troops* and at the same time the needs of civilian activities. The armed forces come first. During the time that the War Department was making up its mind that it needed the A.S.T.P. trainees much more as troops than it needed them as engineers in training, educational agencies, including S.P.E.E., could do little about it. Likewise, there was little that these agencies or those associated with the War Manpower Commission could do when for the same basic reason Selective Service determined that, since it could no longer defer young engineers in industry except in extraordinary cases of irreplaceability, there was no longer a basis for deferments of engineering students in college. Hence most of the A.S.T.P. trainees were sent to troops, and according to a recent announcement of Selective Service, civilian deferments of engineering students will presently end.

However unfortunate, it is yet true that representations to the War Department, or even to Selective Service, that students should be kept in college on any grounds whatever excepting ***military needs*** must be futile. And the Army determines its own needs for engineers, as it does also for doctors. A representation, for instance, that engineering students should be deferred or A.S.T.P. continued in order to keep the colleges going, or for other reasons of civilian welfare, is not, if my understanding is correct, even listened to by the Army or Selective Service; and the suggestion by educators that students should be deferred because war industries need them, is answered by the reasonable question "Why doesn't industry represent its own needs?" It has seemed clearly inevitable for many months that as the young manpower pool became more and more depleted, proposals that engineering students be deferred would be accorded less and less attention by Selective Service unless war industries themselves demanded it; and that war industries would not demand it until they were genuinely pinched for engineers and new engineering graduates. At that point, discovering their in-

ability to produce the requisite war materials for the Army, these industries would be in position to talk convincingly to the Army. Then the latter would have to decide which it wanted, the men or the materials.

That point was first reached in the aircraft industry. In the last few months it has been approached in other industries, notably rubber and other chemical, and in certain branches of electrical. And for this reason, and not because professional or education groups concerned urged it, provision is being made, as recently announced in the press, to defer a very limited number of young engineers in war industries—i.e., in certain specific war plants where such engineers are determined by appropriate agencies to be irreplaceable. But the number of these deferments will be reduced to the utmost. It would thus appear that the much-debated question whether plans should be based on a long war or a short war has been settled in favor of the latter, and the War Department and Selective Service have apparently decided that there is now no reason for deferring engineering students as a replacement pool for this small industrial group of deferred engineers.

Although the activities of the officers of the Society and the Committee on A.S.T.P. have had little, if any, influence on the fundamental decisions referred to above that have drastically reduced enrollments, they have given continued attention to the possible effects of this decision. One serious question occurred which, it seemed, should be raised with the War Department. It was this: if unpredictable developments brought the decision practically to liquidate A.S.T.P. just at the time when, after long and expensive effort, it was approaching full development, is it not possible that new unpredictable developments in the future might bring a decision to resume A.S.T.P? If so, resumption from scratch with faculties dispersed and programs closed would present tremendous difficulties. It simply could not be done overnight. Wishing to be sure that the War Department understand this fact, the Committee on A.S.T.P. approved my sending an appropriate letter to the Secretary of War, and this has been done.

Other A.S.T.P. matters to which attention has been given are those which have related to plans for establishing and carrying on the Program. We have had the most cordial and, within its purview, effective coöperation with A.S.T.D. Incidentally, it will be recalled that the A.S.T.D. does not make policy decisions; it carries out such as are made by higher authority in the Army. We have worked with Colonel Beukema, Director of A.S.T.D.; Dr. A. L. Rubin, Chief of Curricula and Standards Branch; and Lt. Colonel Pumphrey, Chief, Engineering Section, Curricula and Standards Branch. Secretary Bishop and I have been in Washington frequently, and the S.P.E.E. Committee on A.S.T.P. has met from time to time. Occasionally Colonel Pumphrey has attended the meetings, and recently Dr. Rubin spent a day in Pittsburgh to review problems.

One item of the Program on which the Committee did a great deal of work became dead history before it could be put into effect. It was the complete revision of the course outlines of the Basic Phase, looking to more definite statement of objectives, improved sequence, and a reduction in prescribed subject matter. However, just as these outlines were completed and the copy to be published in the S.P.E.E. *Journal* was sent to the printer, the Army discontinued the Basic Phase.

Similar studies were also made of the course outlines for the Advanced Phase. It has not yet been quite discontinued!

Although the Army, I understand, has determined that it now has practically all the engineers it needs, some 3,000 advanced students are still retained. Although there certainly is no assurance, so far as I can determine, that these too will not be sent to troops, it is yet at least conceivable that in view of the situation outlined in the letter to the Secretary of War the group may be somewhat increased so as to form a standby unit.

In any case, Colonel Pumphrey and his associates have studied plans for maintaining the Advanced Phase as now authorized. He has sought the counsel of the Committee regarding these plans, and a meeting was held in Pittsburgh on April 7. The specific plans that were endorsed by the Committee have not yet been approved by the War Department and are therefore not fully outlined here. They relate to sources of new trainees for the Advanced Phase to replace those who complete the work, and to procedures. One suggestion that came out of the meeting was promptly sent in a telegram to the deans of engineering colleges. It was that the transcript to be handed to the deferred civilian student when he is inducted should bear his dean's estimate of what A.S.T.P. Term he is qualified to enter, in case he is sent to the Advanced Phase Program after his basic military training. If the Army gives this estimate the weight it deserves, a large part of the selection problem, so far as these students are concerned, will have been solved.

The Reserve Program is another urgent, current problem. Reserve trainees are not soldiers, are not in the Army. If they are in the Program it is because they chose to be, and they are under no legal obligation to remain. As such they are a special short-term group, and a special program of courses is being planned for them.

The number of Reserves may be significantly increased. It appears now that by next July the number may be upwards of 25,000. There are, however, so many uncertainties involved that my guess on this score is not to be regarded as anything more than a guess. One of the unknown factors is the question whether students who are eligible will elect to join the Reserves. In any case, the probabilities of a significant increase are high enough to warrant the preparation of plans by A.S.T.D.

Such plans are being made. I recently attended two meetings in Washington in this connection. One of them reviewed the practical problems that would be involved in a large increase in the enrollment of Reserves. For instance, a reduction in the requirements for eligibility. Up to now the eligibility requirements for the A.S.T.R.P. have been the same as for the A.S.T.P. In order to make it possible to admit a larger number of trainees, it is planned to include some whose educational preparation has been less extensive. This provision of course poses some practical educational problems. Then there is the question of length of training period, since none will be eligible whose age is less than 17 years, nor more than 17 years and 9 months. The solutions to these and other problems considered at the meeting will be made known if and when they are approved by the War Department. The second meeting had to do with the planning of course outlines. Most of the participants in this case were subject-

matter expects who undertook to construct, under the supervision of Lt. Colonel Miner of the A.S.T.D., course outlines within the framework of the general plan formulated by the first meeting mentioned above. I realize how inadequate my report is regarding these meetings, so far as details and conclusions are concerned, but it will be realized, I am sure, why a full report cannot be made before the plans are approved. My main purpose is to indicate that your officers and the Committee on A.S.T.P. are fully aware of what is going on in A.S.T.D. and, for good or ill, are participating in the deliberations.

Another major problem is the plan for the education of veterans. This matter was reviewed by the Council at the Chicago meeting last October, and a resolution was adopted favoring an administrative plan patterned after that of the E.S.M.W.T. This resolution was passed on to the Committee on the Relationships of Higher Education to the Federal Government (the Day Committee) which was giving consideration to the problem. Also, it was urged upon General Osborn's committee appointed by the President to make recommendations regarding an educational plan for returning veterans. Subsequent to the President's message to Congress presenting a plan based on the report of General Osborn's committee, a number of bills have been introduced. Of these the so-called "Omnibus Bill" S-1767 has taken first place. It has been passed by the Senate, and a bill in precisely the same form (HR-4357) has been introduced in the House. It seems quite certain that it will presently become law. It would place all matters, including the educational plan, under the control of the Administrator of Veterans' Affairs. The importance of the provisions of this bill to engineering education is very great, and I would strongly recommend that members of the Society, especially those who have administrative responsibilities, study the bill. The problem is one which Dean MacQuigg's committee of the Administrative Division is giving attention.

The question of universal military service has been under consideration in Washington, and definite proposals (HR-1806 and HR-3947) have recently been formulated in Congress. If provisions for such service are finally enacted, as seems likely, new problems will face engineering education. As indicated in the bulletin of the American Council on Education, dated March 30, 1944, the Day Committee has recommended that the final formulation of law be postponed until after the war. The S.P.E.E. Committee on Engineering Education After the War has given study to this question as it relates to the programs of engineering education, and the officers of the Society are following developments in the matter.

The possibility of obtaining apparatus for engineering colleges from the Committee on Government Surplus Property was discussed by the Council last October, and a committee under the chairmanship of Dean MacQuigg was appointed at that time to pursue the possibility. He has recently indicated that his committee is in active contact with the Director of the Committee on Government Surplus Property in an effort to determine a way in which the engineering colleges can most effectively deal with this matter.

Still another problem looms now. It grows out of the plan sponsored by the federal government to provide training for young engineers from foreign countries, especially from devastated areas. A meeting was held in Philadelphia some

weeks ago under the auspices of the Hazen Foundation at which the plan in very general form was reviewed. The Society was represented by Dean Disque whose interesting report has been referred to Dean MacQuigg, Chairman of the Administrative Division. The plan is being formulated by the Foreign Economic Administration, which has already drafted definite programs for certain specialized engineering courses at a few industrial centers. The programs will be for college graduates principally from foreign colleges, although the plan may also include some graduates of the United States colleges. The length of the programs is eighteen months, and the time will be spent partly in college, partly in industry, the purpose being to shorten the time traditionally required between graduation and the point where the young engineers can assume professional responsibility. Although I cannot report as to the final magnitude of this project, my understanding is that it may reach substantial proportions. In any case, it is another problem to which the Administrative Division is giving attention.

Finally, I wish to report the most gratifying progress which Dean Hammond's Committee on Engineering Education After the War has made in its very difficult assignment. According to present plans, the report, which has gone through four revisions during the process of study by the Committee and review by many persons outside the Committee membership, will appear in the May issue of the *Journal*. I should like to venture the opinion that this report will prove to be one of the most important contributions to education ever published.

May I conclude with the suggestion that every member of the Society who can possibly do so attend the Cincinnati Convention on June 22–25. The theme of the convention is "Engineering Education After the War." One general session will be devoted to the report of Dean Hammond's committee, and there will be other aspects of post-war problems discussed in the conferences. Another session will be devoted to a matter closely related to engineering education in the post-war period; namely, a report regarding the Measurement and Guidance Project in Engineering Education, sponsored jointly by the S.P.E.E., E.C.P.D., and the Carnegie Foundation. So I hope there will be a full attendance at the Convention.

New Members

BADLEY, JOY E., President, Tractor Training Service, 610 Mead Bldg., Portland 4, Ore. R. A. Seaton, M. A. Durland.

BRYAN, NOAH R., Associate Professor of Mathematics, University of Maine, Orono, Me. Paul Cloke, W. S. Evans.

CLIFFORD, ALBERT C., Engineer, Personnel Dept., Western Electric Co., Kearny, N. J. Otto Carpenter, D. S. Bridgman.

CLOSE, GEORGE D., Factory Office Personnel, Goodyear Tire and Rubber Company, Akron, Ohio. T. W. Prior, F. L. Bishop.

CRANE, EDWARD M., President, D. Van Nostrand Co., Inc., 250 Fourth Ave., New York City. J. S. Thompson, E. P. Hamilton.

CUMBERLAND, ROBERT W., Assistant Professor of English, The Cooper Union, New York City. W. S. Lynch, E. S. Burdell.

DIXON, WISTAR R., Application Engineer, Westinghouse E. & M. Co., East Pittsburgh, Pa. H. C. Madsen, E. E. Pendray.

FURRY, WARREN G., Supervisor, Engineering Training, Lockheed Aircraft Corp., 1416 Lee Drive, Glendale, Calif. R. T. Brown, F. L. Bishop.

GERHARDT, ROYAL M., Assistant Dean, School of Engineering, Professor of Architectural Engineering, The Pennsylvania State College, State College, Pa. F. T. Mavis, C. L. Harris.

GODIN, CAMILLE R., Assistant Professor of Mathematics, Ecole Polytechnique, Montreal, Canada. A. Circe, H. Gaudefrey.

GRAVES, HARRY P., Sales Manager, College Dept., McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y. J. S. Thompson, Nell McKenry.

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JOHNSON, CHARLES F., Research Physicist, The Bristol Co., Waterbury, Conn. F. L. Bishop, Nell McKenry.

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KING, DAN M., Librarian-in-charge, Cooper Union, New York City. E. S. Burdell, D. K. Maxfield.

KRUMLAUF, HARRY E., Associate Professor of Civil and Mining Engineering, Michigan College of M. and T., Houghton, Mich. C. H. Baxter, L. A. Rose.

MATSON, ROBERT C., Associate Professor of Civil and Mining Engineering, Michigan College of M. and T., Houghton, Mich. C. H. Baxter, L. A. Rose.

MILLER, BENJAMIN, Chairman, Div. Education and Basic Research, Inst. Gas Tech, Illinois Institute of Technology, Chicago, Ill. H. T. Heald, R. C. Kintner.

MONTGOMERY, O. DUNCAN, Supervisor, Student Training, Westinghouse E. & M. Co, East Pittsburgh, Pa. H. C. Madsen, E. E. Pendray.

OWENS, RALPHY G., Superintendent of Thermodynamics, Armour Research Foundation, 35 W. 33 St., Chicago, Ill. W. E. Wilson, C. O. Harris.

SHEPHERD, MARSHAL L., Major, Assistant Professor Military Science and Tactics, North Carolina State College, Raleigh, N. C. R. L. Stone, E. W. Winkler.

SKRODER, CARL E., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. R. P. Hoelscher, A. R. Knight.

TOWNSEND, ERNEST J., Assistant Professor of C. and M. E. and Economics, Michigan College of M. & T., Houghton, Mich. C. H. Baxter, L. A. Rose.

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YORK, VERNO O., Assistant Professor of Electrical Engineering, Michigan College of M. & T., Houghton, Mich. L. A. Rose, G. W. Swenson.

280 new members to April 12, 1944

Analytic Geometry

By FRED E. AYER

Dean, College of Engineering and Commerce, University of Akron

This article is based upon thirty-eight years of cumulative, mathematical ignorance, and, unless those hard-shelled mathematical Baptists, who believe that nothing short of total immersion will suffice for scientific conversion, write me the abuse which I deserve, I shall be grievously disappointed.

My experience leads to these two conclusions:

1. The majority of mathematicians regard mathematics as a science.

2. The majority of engineers regard mathematics as a tool.

Therefore, the engineer is not interested in mathematics except as he can use it in the furthering of his professional objectives.

Assuming that the student—or the engineer—has an adequate working knowledge of algebra, trigonometry, and descriptive geometry; would he ever use the methods of analytical geometry to find:

The distance between two points.
Area of a triangle or polygon.
Division of a line into a given ratio of parts.
Slope of a line.
Angle between two lines.
Bisector of the angle between two lines.
Equation of a line through a given point with a given slope.
Equation of a line through two given points.
Line through the point of intersection of two given lines.
Distance from a point to a circle along a tangent.
Rotation of axes in order to remove the "xy" term.
Or to recognize and plot rose-leaved curves, limaçons, strophoids, witches, and other Halloween goblins.

The following is a quotation from a very good text in Analytic Geometry:

"Work the following exercises without finding the point of intersection of the given lines."

Then follow exercises which would take the average student one to two hours to work. We spend four years trying to teach a student that "the engineer is one who can do for one dollar what any darned fool can do for two;" that he must be continually on the lookout for easier and better ways of doing his work, and then along comes a text-book which directs him to do a job the hard way just for the hell of it.

Now on the constructive side, most teachers will agree that analytic geometry does have value as a visualization of algebraic equations. Then why not teach that part of the subject which has little or no utilitarian value along with, and as a part of algebra. Such procedure would allow more time for solid analytics which has applications in calculus and mechanics. And, perhaps, time to teach how to formulate an equation to fit a given collection of data.

Correspondence invited.

How Well is the E.S.M.W.T. Program Serving War Production Training Needs?

By ROY W. BIXLER

Educational Statistician, Engineering, Science, and Management War Training Program, U. S. Office of Education

General Purpose of the Study

The Engineering, Science, and Management War Training Program is sponsored by the Federal Government for the definite purpose of meeting a vital need in training personnel to relieve specific shortages in war industries and the armed forces—for immediate service in specialized fields. There are strong indications, especially in many letters from employers, that the participating institutions are doing a splendid job of determining training needs and operating appropriate courses. While there is strong justification of confidence in the efficacy of the program in this respect, members of the staff in Washington are constantly seeking verifying evidences. Such was the motivation of this study.

Specific Objectives

The study had two closely related objectives: (1) to determine how well the Program is succeeding in placing training activity in the localities where war production is going forward, and (2) to determine how sensitive and responsive the program is to the condition of the labor market. It was assumed, first, that war production creates a need for technically trained personnel in the localities where it is going forward, and, second, that labor shortage creates a similar demand in the shortage areas. The effectiveness of the Program in responding to these demands should be a significant indication of how well it is serving war production training needs—the question set up as the title of this paper.

Sources of Data and Method

Two kinds of data were available: (1) statistics on the volume of war production by states, as reported by the War Production Board, and (2) information on the adequacy of labor supply, by labor market areas, as reported by the War Manpower Commission. The problem, in the use of the first was to determine the correlation between the volume of training activity and the volume of war production, because if the Program is functioning as it should these two variables should be positively correlated to a significant degree. In the case of the second, the problem was to discover to what extent training activity is being concentrated in areas of labor shortage.

The rank correlation procedure was used in the part of the analysis based on statistics of war production. Enrollment was used as the index of volume of training activity and the dollar value of war supply contracts

awarded, as the index of volume of war production. The states were ranked on these indices and the correlation of the ranks obtained.

In the part of the analysis based on adequacy of labor supply, it was necessary to devise a measure of concentration of training activity. The ratio of enrollments per hundred thousand population was selected as the most practical index. This index is referred to in the study as the *enrollment-population ratio.*

The War Manpower Commission classifies the areas in which there are actual or anticipated problems of labor supply in four groups defined as follows:

Group I.	Areas of acute labor shortage
Group II.	Areas of labor stringency and those anticipating a shortage within six months
Group III.	Areas in which a slight labor surplus will remain after six months
Group IV.	Areas in which a substantial labor surplus will remain after six months

In setting up these groups, the War Manpower Commission has defined four degrees of adequacy of labor supply, ranging from critical shortage in Group I to remote shortage in Group IV. Included in the four groups are all of the labor market areas in which there is a city of 2,500 population or more, or in which there is a special problem of labor supply. By this definition all areas not included in the four groups are free from problems of labor supply. These areas were combined in the study as a fifth group in which it is assumed that problems of labor supply are even more remote than in Group IV.

The labor market information was taken from a War Manpower Commission report of November 1, 1943, entitled *Adequacy of Labor Supply in Important Labor Market Areas.* The enrollments used in the enrollment-population ratio were those in courses active a month later, on November 30. The active enrollment of this date was judged to be in the proper time relationship to the labor market information.

Findings

Training and War Production

The correlations are first indicated roughly by comparing percentage distributions of enrollments in five categories of states, based on the volume of war supply contracts awarded to industries within them. For example, it was found that the states which had 89.6 per cent of the war supply contracts in the three fiscal years, 1941, 1942, and 1943, corresponding with E.D.T., E.S.M.D.T., and E.S.M.W.T.–I, had 81.0 per cent of the enrollment in the three programs. Also, the states that had 88.3 per cent of the war supply contracts in 1943 had 75.9 per cent of the enrollments in E.S.M.W.T.–I.

The war supply contract figures were available for aircraft and shipbuilding separately, which together make up nearly 50 per cent of the total. This made it possible to relate enrollments in courses designed for these industries to war production in the industries. The states that had 86.8 per cent of the aircraft war production were found to have 75.6 per cent of the enrollments in courses designed for aircraft workers. And the states that had 70.3 per

cent of the shipbuilding were found to have 57.3 per cent of the courses for shipbuilding workers.

All of the coefficients of correlation obtained (ranging from .62 to .89) are positive and large enough to be regarded as highly significant. In Table I

TABLE I

CORRELATIONS BETWEEN THE RANKS OF THE STATES IN VOLUME OF ENROLLMENT AND VOLUME OF SUPPLY CONTRACTS

Program and Year	Coefficient of Correlation	Standard Error
E.D.T. (1940–1941)	.80	.054
E.S.M.D.T. (1941–1942)	.71	.074
E.S.M.W.T. (1942–1943)	.86	.039
All Programs (1940–1943)	.89	.031

are the correlation data for the three programs separately and combined. In Table II similar data are shown for aircraft and shipbuilding (1942–1943, program) in which the correlations

TABLE II

CORRELATIONS BETWEEN THE RANKS OF THE STATES IN VOLUME OF ENROLLMENT IN TWO TYPES OF COURSES AND VOLUME OF SUPPLY CONTRACTS IN CORRESPONDING WAR PRODUCTION

Type of Course and Kind of Contracts	Coefficient of Correlation	Standard Error
Aeronautical Engineering Courses and Aircraft Contracts	.82	.049
Marine Engineering and Naval Architecture Courses and Ship-building Contracts	.82	.092

were obtained from the ranks of the states in volume of war supply contracts in the industry and enrollments in related courses.

In Fig. 1 the relative ranks of the states, based on 1941–1943 figures (three programs combined), are shown graphically. This diagram represents a correlation of .89 as indicated in Table I. In several states the correspondence between the two ranks are out of line with the situation as a whole, as indicated by the coefficient of .89. Probably most of these variations could be explained in terms of adjustments to peculiar situations, adjustments which are a credit to the participating institutions in the states and detract in no way from the effectiveness of the program. Some of the states, for example, in which there are rather large war production programs, such as Kansas, Texas, and Alabama, are agricultural states. In these states the supply of technically trained personnel was very inadequate at the beginning of the war, so large training programs were necessary. The opposite situation is presented by Michigan which has been highly industrialized for many years. In her peace-time industries there was a large pool of technically trained personnel available immediately for war production. Consequently, her training needs were relatively small. Some states are training for industries in other states. Colorado, for example, is doing a considerable amount of training for California and Washington. The Pennsylvania program also feeds into adjacent states. The District of Columbia, which has the greatest difference in the ranks, is of minor importance industrially, but contains many Government agencies with technical staffs for which a considerable volume of training has been required.

These illustrations tend to document an inference that where there is poor correspondence between volume of

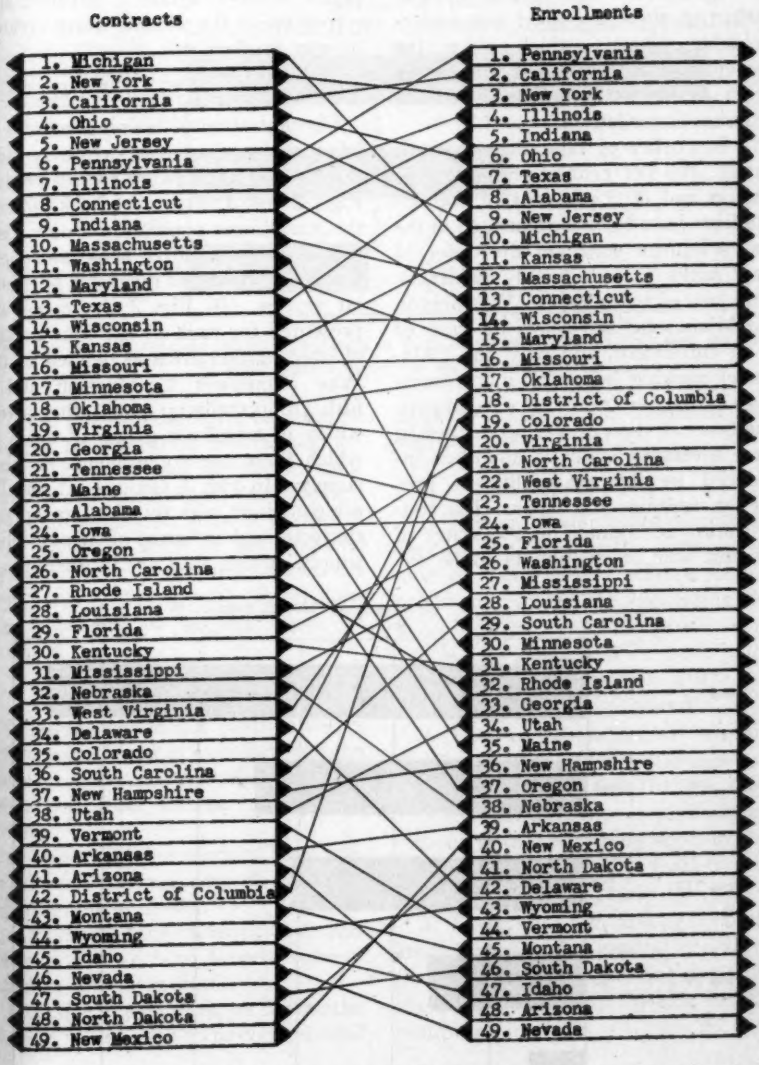

FIG. 1. Relative ranks of states in amount of war supply contracts and enrollments in E.D.T., E.S.M.D.T., and E.S.M.W.T.–I

training activity and volume of war production there are good and understandable reasons which place the discrepancies on the credit side of the ledger as far as the efficiency of the Program is concerned.

It is worthy of note that approximately 90.0 per cent of the war production and 80.0 per cent of the enrollments have been concentrated in the first seventeen states in the order of their ranks in war supply contracts. Only two of these states (Washington and Minnesota) fall below the rank of 17 in enrollment, and only one (Alabama) ranking below 17 in contracts takes a higher rank in enrollments. The concentration of war production in these seventeen states is doubtless influenced by the availability of production facilities and labor. The concentration of training in the states of heaviest war production is to be expected if the Program is sensitive and responsive to the training needs created by war production.

Training and the Labor Market

Concentration of training activity in labor shortage areas is definitely indicated. The findings are summarized in Figs. 2 and 3, where the bars indicate the enrollment-population ratios (enrollments per hundred thousand population). These two diagrams tell similar stories. In Fig. 2 the ratios are presented for each of the four groups of labor market areas as defined by the War Manpower Commission and a fifth group made up of all other areas, which is actually a group of areas in which there are no problems of labor supply. In Fig. 3, Groups III and IV are combined with this fifth group and characterized as "areas of surplus labor supply" which they are by definition.

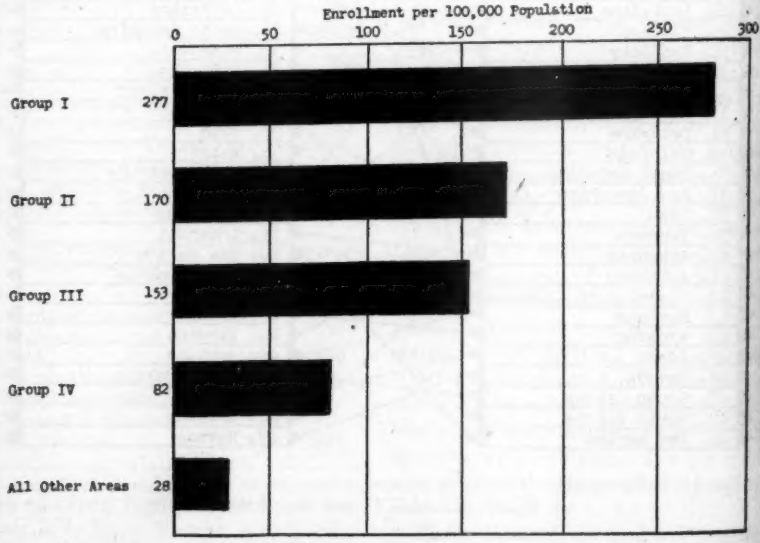

FIG. 2. Enrollments per 100,000 population in War Manpower Commission's four groups of labor market areas and all other areas

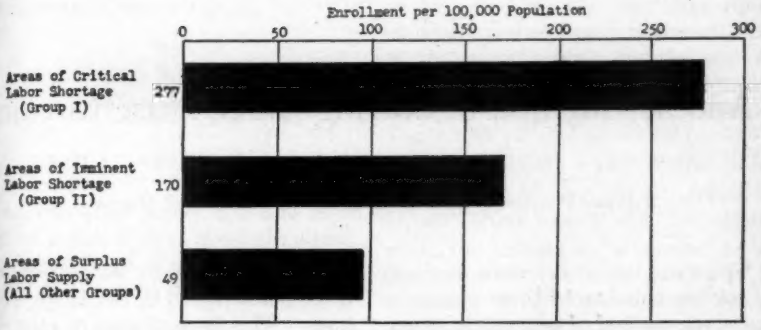

FIG. 3. Enrollments per 100,000 population in War Manpower Commission's four groups of labor market areas and all other areas

These diagrams indicate an unquestionable concentration of training activity in areas of labor shortage. Compare the 277 enrollments per hundred thousand population in areas of critical labor shortage with 28 per hundred thousand in non-problem areas, as shown in Fig. 2, and with 49 per hundred thousand in surplus areas, as shown in Fig. 3.

SUMMARY OF FINDINGS

1. Highly significant positive correlations were found to exist between the ranks of the states in volume of war production and volume of training activity.

2. These high correlations have prevailed since the beginning of the training program in 1940.

3. Both training activity and war production have been largely concentrated in seventeen states.

4. Active enrollments, on November 30, 1943, were found to be concentrated in areas of critical and imminent labor shortage.

CONCLUSIONS

1. The highly significant correlations between the ranks of the states in volume of training and volume of war production justify the conclusion that E.S.M.W.T. and her predecessors, E.S.M.D.T., and E.D.T., have placed training in the localities where war production was going forward.

2. The concentration of training activity in areas of labor shortage warrant the conclusion that the 1943–1944 E.S.M.W.T. Program is sensitive and responsive to the training needs created by conditions of the labor market in the war production program.

3. Therefore, the findings of this study warrant the general conclusion that E.S.M.W.T. is serving the training needs created by the war production program.

Another Method of Solving Three-Phase Circuits

By D. L. WAIDELICH

Assistant Professor of Electrical Engineering, University of Missouri

There are two well-known methods of solving unbalanced three-phase circuits, the method of symmetrical components and the elementary application of Kirchhoff's laws. There is another method of solution which involves the application of the superposition theorem and has been used by the author in two ways, first, as an application of and source of problem material for the superposition theorem and second, as an alternative method of solving unbalanced three-phase circuits. In this last way it has the advantages of reducing the three-phase problem to that of two or three single-phase problems and also of producing the desired current or voltage without solving for any of the other currents or voltages. In the succeeding paragraphs two problems will be solved, one of an unbalanced three-phase circuit without a neutral connection which reduces to two single-phase problems, while the second has a neutral connection and must be solved as three single-phase problems.

A three-phase line without a neutral connection may be considered to act as if it were composed of two separate single-phase lines, one for each of two of the three-phase line voltages. The third line voltage is the sum of the other two line voltages and thus may be disregarded. In a problem of an unbalanced load then, the solution may be obtained by considering the three-phase line to be two single-phase lines. This is analogous to the fact that two equations result when Kirchhoff's laws are used to solve a problem of this type. The superposition theorem may then be applied, and the solution of the problem obtained. As an example an unbalanced three-phase voltage is applied to an unbalanced wye load without a neutral connection as shown in Fig. 1. If the sequence

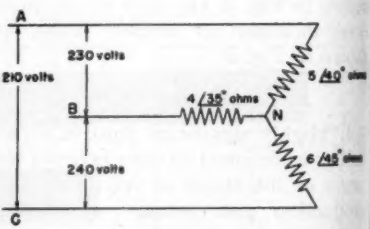

FIG. 1. An unbalanced three-phase wye circuit with an isolated neutral.

is assumed to be ABC, the solution of the line voltage triangle gives $V_{AB}=230\,\underline{|\,0°}$, $V_{BC}=240\,\underline{|\,-127°}$, and $V_{CA}=210\,\underline{|\,114.4°}$. The two line voltages, V_{AB} and V_{BC}, will be the ones used in the solution, and the current to be solved for is I_{AN}, the current in the A line. If the line B is shorted to line C (V_{BC} short-circuited) and the voltage V_{AB} applied to the circuit,

the current in the A line is

$$I'_{AN}=\frac{230\,\angle 0^\circ}{5\,\angle 40^\circ+\dfrac{(4\,\angle 35^\circ)(6\,\angle 45^\circ)}{4\,\angle 35^\circ+6\,\angle 45^\circ}}$$

$$=31.1\,\angle -39.9^\circ.$$

If, on the other hand, the line A is shorted to line B (V_{AB} short-circuited) and the voltage V_{BC} applied to the circuit, the current in the A line is

$$I''_{AN}=\frac{240\,\angle -127^\circ}{6\,\angle 45^\circ+\dfrac{(4\,\angle 35^\circ)(5\,\angle 40^\circ)}{4\,\angle 35^\circ+5\,\angle 40^\circ}}\times\frac{4\,\angle 35^\circ}{4\,\angle 35^\circ+5\,\angle 40^\circ}$$

$$=13.01\,\angle -172.67^\circ.$$

The total current in line A is the sum of the two currents obtained above: $I_{AN}=I'_{AN}+I''_{AN}=24.15\,\angle -63^\circ$ amperes. The other currents may be obtained in a similar way.

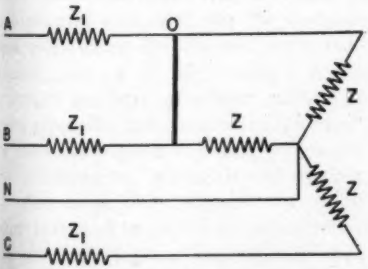

FIG. 2. A balanced three-phase wye circuit with a neutral connection. A short circuit is present at O.

As another example of the use of this method, the solution of the three-phase circuit with a neutral connection shown in Fig. 2, will be carried out. In this case three voltages must be used, as indicated by the fact that three equations are necessary in the solution of the same circuit by the use of Kirchhoff's laws. The three voltages used are the balanced phase voltages, $V_{AN}=2300\,\angle 0^\circ$, $V_{BN}=2300\,\angle -120^\circ$, and $V_{CN}=2300\,\angle +120^\circ$ volts. The impedances of the circuit are $Z=12\,\angle 30^\circ$ ohms and $Z_1=3\,\angle 75^\circ$ ohms, while the unbalance is caused by a line-to-line short circuit at O. It is necessary to solve three single-phase problems in this case, one for each of the three-phase voltages. When solving for the current in line A under short circuit, the voltage V_{AN} is used with both B and C shorted to N. The resulting current is

$$I'_{AO}=\frac{2300\,\angle 0^\circ}{3\,\angle 75^\circ+\dfrac{(3\,\angle 75^\circ)(6\,\angle 30^\circ)}{3\,\angle 75^\circ+6\,\angle 30^\circ}}$$

$$=451\,\angle -68.9^\circ.$$

With the voltage V_{BN} applied (A and C shorted to N):

$$I''_{AO}=\frac{-2300\,\angle -120^\circ}{3\,\angle 75^\circ+\dfrac{(3\,\angle 75^\circ)(6\,\angle 30^\circ)}{3\,\angle 75^\circ+6\,\angle 30^\circ}}\times\frac{(3\,\angle 75^\circ)(6\,\angle 30^\circ)}{3\,\angle 75^\circ+6\,\angle 30^\circ}\times\frac{1}{3\,\angle 75^\circ}$$

$$=322.3\,\angle -23.53^\circ.$$

Similarly for V_{CN}:

$$I'''_{AO}=0.$$

The total current I_{AO} in line A is

$$I_{AO}=I'_{AO}+I''_{AO}+I'''_{AO}$$

$$=716\,\angle -50.2^\circ \text{ amperes.}$$

The other currents may be obtained by a repetition of the above process.

This method may also be applied when two or more sources are operating on the same circuit. If two sources are present, one source should be short-circuited, while the currents from the other source are determined. Then short-circuit the latter source and find the currents from the former one. Again the sum of the currents will be the actual current present in the circuit. The method may also be used for any number of phases, although only three-phase problems have been considered here.

English in Basic Army Courses

By ALEXANDER M. BUCHAN
Washington University

> . . . we believe that science, mathematics, and engineering subjects, properly presented and interpreted by men of urbanity and culture, are as valuable parts of a liberal education as history and literature and the fine arts.*
>
> FRANKLIN BLISS SNYDER,
> President,
> Northwestern University

The value of English for technical students is freely conceded by the inclusion, in the basic curriculum for flight, meteorology, and engineering detachments of the Army, of a "communication" course. This curriculum is severely scientific and technical in outline and aim, and yet the committees organizing the courses seem convinced that it is not enough for a technical student, of officer caliber, to have scientific information in his head; he must also have the skill to convey the information, in speech and writing, to men under him as well as to his superiors and to the War Department. "It is of the highest importance," said a statement from Army Air Forces Technical Training Command (May 4, 1943), "that officers in the armed forces, and especially weather officers, be able to express themselves clearly, concisely, and accurately, in writing and speech."

It is possible, of course, to consider both English and History as courses in indoctrination. The statement already cited goes on to say that "the Army also desires its officers to be well-informed citizens, intelligently aware of the traditions and history of their country and of the nature and scope of the struggle in which we are now engaged." The majority of the popular textbooks in English being turned out for these courses have a noticeably doctrinal slant, as a glance at their tables of contents will show. However, the local academic supervisor of "communication," while expected to coöperate closely with the other departments, is left free to select his textbooks, so that his chief responsibility appears to be what the title of the course suggests—the one of seeing that his students learn to communicate in speech and writing, at the same time as they gather, in scientific courses, the materials to communicate.

Here, it would seem, is an experiment on a very large scale, the process and results of which ought to be carefully watched. The place and importance of English in schools of engineering, as in other technical schools, came in for a good deal of discussion before the war; and what these schools

*From a speech delivered at the 50th Anniversary Meeting (English), S.P.E.E., Chicago, June 18–20, 1943.

were doing, in a tentative and sporadic fashion, is now being carried out in most of the large and some of the small colleges in the country. The thoroughly practical values desired in the basic English for the Army are similar to the values that engineers found desirable in English for engineers, although the four-year-old report of the S. P. E. E. Committee also asked for a number of "cultural" benefits as well. At all events, an experiment is being made in the interests of emergency, and it would be unfortunate if the teachers and supervisors who are handling the English courses fail to make a record of plans and results. Any useful conclusions must wait on an accumulation of evidence from a large number of teachers, but a hint of some of the problems may help, even at this stage.

Problem of the Teacher

Underlying the whole program in "communication" are two assumptions: 1, that the teachers of the courses are teachers either of speech or composition; and 2, that the material of the courses is predominantly technical. Most teachers of composition belong to departments of English. The specialty of the majority of them is literature, its history, philosophy, and appreciation. While it is true that wartime shortages have left few departments intact, so that any English department may be using teachers of languages or philosophy, or even chemistry, the teaching staff of the Army programs will, if drawn from departments of English, be specialists in literature rather than in history, or geography, or mathematics, or physics. The teacher of speech may have a broader range than the teacher of English—more rhetoric, phonetics, political science, or economics—but he is no bette equipped, from the standpoint of i formation, to judge material in meteo ology, engineering , or navigation th the teacher of English.

Yet he and the teacher of Englis composition are given the responsibili of teaching communication of materi that the programs insist shall be tec nical for the most part. This insis ence, while not actually enforced, i taken for granted always. The Un versity Meteorology Committee, for i stance, gave a summary of the duti of weather officers as related to th course in communication. These duti included interviews of weather perso nel, classes in meteorology (includi calculus), climatic reports, weather re ports and operations, refresher cours in weather—all technical assignment In most of the directives on the co munication course, strict emphasis i laid on the necessity for coöperati between this course and the others, a of which, with the possible excepti of history, are scientific. The cour in communication, that is to say, b comes the clearing-house for the oth technical courses. It gives the Arm students an opportunity to discu orally and in writing, the substance history, geography, mathematics, a physics—with some slight permit entry to the broad and rather nebulo field of the usual course in speec And the instructors, generally spea ing, will know less tbout any one these specialties than the students th are teaching.

Problem of the Student

The difficulty of "integration" is n one of the teacher's equipment onl it is also concerned with the amount the student's information and his sta of progress in a technical field. To th

teacher of English or speech the difficulty is not new, since his classroom has been the catch-all of notions from many sources, from the *Reader's Digest* at one end to the student's latest lecture on the Feudal System at the other. And the difficulty has been obvious: not enough facts for the notion, and not enough notion for the quantity of words. In order to find writing or speech emptier of substance than a freshman theme or a sophomore's speech, one must go to the files of the Congressional Record. The Army program insists on substance—the substance of history, geography, mathematics, physics being poured into the trainees in other classes. Yet the teacher of communication is soon convinced that the substance isn't there and cannot be there in the fog created in the student's minds by a bout of highly concentrated application to a number of new subjects. Vague notions of history or geography make the worst sort of basis for communication—vague notions indeed of any sort. Although it is true that an attempt at expression in speech or writing helps to clear up vague notions, the effort is rather pointless unless ample time is available for filling in the structure of substance and fact on which ideas rest.

The fault does not lie with the teaching in other courses. No material in a new college course is fit substance for English expression until time is allowed for its assimilation. When the force-feeding of the classroom is joined to the slower digestive process of discussion and additional study, the teacher of English can begin to take charge. An instance of this happy conjunction may be mentioned. A week or two ahead of the history and communication examination set by the Meteorological Committee, Dr. D. Bryant, the academic supervisor of Course V in Washington University, drew up a list of possible questions in history and turned his staff loose on them. The staff, mostly teachers of English, became teachers of history pro-tem, and worked out with their students, from textbooks and notes, rather full answers to most of the questions. A theme was written on one of the topics, a speech was made, and a chance for class discussion was taken at any time. This was the first history assignment to come alive, because students and teachers both gained an inkling of the technique of historical development and debate.

The comparative success of such a plan indicates that "integration" between a course in English and courses in history and geography may not be impossible. If the students have time for additional study, and if the teachers of communication are willing to study along with them, the themes and speeches produced may be satisfactory. However, it is apparently the hope of the committees arranging the Army programs to integrate the course in communication with courses in mathematics and physics, and immediately fresh difficulty arises.

Problem of Technical Subjects

So as to understand this difficulty, it may be helpful to refer to a similar problem already met by teachers of engineering students. An English instructor of engineers, anxious to give his students a chance to talk or write about subjects of interest to them, sends them to the technical magazines and to the *Industrial Arts Index*. The student who follows this recommendation is quickly in trouble. Either he contents himself with the vague, unsubstantiated, popular accounts of sci-

ence found in bookstall magazines; or, plunging into authoritative magazines, he finds himself out of his depth. The chemical engineering student falls back on the formulæ of chemistry, only the simplest of which have any meaning for mechanical or civil engineers—or for the teacher! Other students use familiarly technical terms of their profession that are little more than sounds to their neighbors in class.

The problem is two-fold: 1, the basic language of mathematics consists of symbols and figures, not of words; and a good part of the basic language of engineering consists of graphs and diagrams, not of words: and 2, where words are used, many of them—in fact, the most important ones—are highly technical, a foreign tongue to the lay person.

The symbolism of the language of even applied mathematics was made clear to the writer by Dr. Frank Bubb. He was attempting, with considerable patience, to explain the configuration of some of the photoelastic designs of stresses in materials, What, I asked him, was the precise significance of a pattern where the lines of stress converged, or of another pattern where the lines, as on a contour map, by lying close together, seemed to indicate a sudden increase in stress? In the end, Dr. Bubb gave up the attempt to explain. "You and I," he said, "speak different languages. I explain these diagrams in my own language, which is mathematics. You explain poetry to me in words, or try to. And there doesn't seem to be any common ground for the two kinds of communication." For physics and chemistry the problem is almost as acute. Except for a description of apparatus, its kind and set-up, the language of these sciences degenerates, according to the teacher of English, into mathematical and chemical formulæ; and the more significant the experiment the more exclusive the formulæ become.

Is such language permissible in a course on communication? Up to a point, perhaps, since it is advisable for even the teacher of mathematics to speak his formulæ articulately. Much of the weather information broadcast by weather officers is given in code, and the mere ability to enunciate clearly has its value. One doubts, however, if a theme would be acceptable written in calculus or in chemical equations, and certainly speeches made in mathematical or chemical symbols would be dull outside a learned society.

The question then arises: Is there any common ground shared by the scientist and the well-informed layman? Is the language of mathematics as different from the language of every day as Dr. Bubb seemed to believe? How much can be borrowed from the technical course to form the substance of a course in speech and writing? This, it seems, is a crucial question, if ever the course in English for technical students is to have any bearing on the students' interests and preoccupations.

Any textbook in any of the sciences proves at once that there must be a common ground, because the textbook, while sometimes termite-ridden with formulæ, also uses the words of common speech. Bringing the matter down to the popular level, any issue of *Fortune* magazine, in one article or another, successfully presents the secrecies of science in a language of the street, which is also the language of a course in communication. An important distinction, that is to say, must be made between the mathematical and chemical formulæ underlying a technical course and the description of their en-

bodiment in apparatus or in objects of practical use. The aerodynamic theory, for instance, underlying the construction of a propeller is, I have been told, quite intricate; but the propeller itself can be described in words—words that may not satisfy a designer but which enable ordinary people to distinguish between a propeller and an egg-beater. The blueprints of mechanisms that control the propeller's pitch cannot be read by a mere teacher of English or understood by his students; but a description of the mechanisms, apart from a few technical terms, must be given in words before the device can be cleared through the Patent Office. For many years Dean A. S. Langsdorf has insisted that the ability to write out and follow patent specifications is a requisite for a college-trained engineer, and no better training in technical communication can be imagined.

For the English teacher the line of division between what is explainable in words and what is explainable only in formulæ or in technical terms becomes a nice problem. It seems advisable, on the whole, to refuse to accept formulæ, save only the simplest. Graphs are acceptable, provided they are fully discussed in terms of actual instances plotted on the curve. Any sort of diagram is welcome if it is not too intricate. Technical terms, across a rather wide range of scientific subjects, must be allowed—such terms as "grid," "viscosity," 'torque," "Brinell test." If the teacher is puzzled about a term or a diagram that all of his students follow readily, he must put himself to school.

While the teacher of mathematics and physics, then, specializes in analysis, the teacher of communication confines himself to description. The latter, in order to encourage students to use their new technical vocabularies, must allow a good deal of freedom. If training of the sort is to be helpful, either to Army trainees or to students of engineering, the English teacher must forget the prohibitions of the old textbooks of rhetoric against the use of "jargon." There can never be, in the English classroom where technical students are learning, the old notion of a fixed quantity of acceptable and inacceptable terms. Any word or phrase needed to denote the most recent scientific advance is admissible, provided the student uses it with some knowledge and precision. A student of chemistry, for example, discussing experimentation in oils for aircraft engines, will be allowed to refer to "viscosity" as if everybody knew what the word meant. Another student, describing routine methods of testing the viscosity of oils, may have to be urged to explain, as well as he can—not to the analytical lengths of the petroleum chemist, but in terms of analogies and comparisons—what a viscous liquid is.

In any plan, therefore, of an English course tied closely to the subject-matter of other and technical courses, at least two requisites appear.

1. A clear notion of what technical material can usefully be handled in an English classroom, and what cannot.

2. A teaching staff familiar with the permissible material in technology as well as with the practice of composition and of speech.

An experimental survey of material was made several years ago in the School of Engineering of Washington University. A responsible member of each department in engineering was asked to draw up a list of topics in his own field that he considered suitable for the English classroom. When these suggestions were pooled, a wide vari-

ety of topics was available, all the way from recent methods of road construction to the description of a simple radio tube. Every year since the survey was made and many of the topics proposed to the teachers of English, additional material has been added by the students themselves from their own limited experience and knowledge.

The results of this emphasis have been noticeable on the teaching staff—or at least those members who carry the burden of teaching engineers from year to year. They learn from their students. An interest in technical subjects has been born, and the old literary bias against them is disappearing. A notion of culture as an attitude assumed towards any subject, technical or philosophical, rather than as familiarity with certain arts and books begins to appear, and the teacher of Wordsworth or Thoreau finds himself engaged, and happily, in discussing baking methods or the development of alloys. For the teacher of speech, too, there can be a realization that the orderly description of a coke-oven is just as valuable practice as an argument on Fascism.

One further advantage of the Army work—an advantage that began as a handicap—is to be found in the emphasis placed on the classroom at the expense of work outside. If programs were to be completed in the allotted time, study periods had to be reduced far below the proportion usually found suitable in college work. While it is true that some of the values of college training are lost by haste, considerable benefit may also accrue. The teacher must "clear his desk" as he goes along. He may not leave a theorem half-explained, hoping that students will get the rest of the explanation by working problems. He may not pour out masses of his own research, trusting that a class will gather the known facts and a clear outline from reading a text. He must finish the work in class. If there are errors to eliminate, they must be so scored in class that they do not recur. If, in the English classroom, ideas are lacking, time must be taken out from other matters to supply ideas. In fact, the teacher of a class that has little or no time for outside preparation must himself be both teacher and text.

For the English teacher of engineers, as of Army trainees, the moral is fairly obvious. His English and his knowledge of practical matters are of almost equal importance. In order to carry out his duties well, he may have to forget *Paradise Lost* for the time being and become a student, if only an amateur one, of science and technology.

The Humanities in Engineering Colleges After the War*

By Robert L. Shurter
Case School of Applied Science

He would indeed be a rash man who attempted to prophesy the exact proportions of the Humanities programs in the post-war engineering college. Nevertheless, if a few general assumptions are made on the basis of present events, it should be possible to forecast the things that are likely to occur—and I shall begin by stating the premises on which my conclusions are based.

In the first place, it seems probable that the liberal arts colleges will be under greater compulsion to reëxamine their curricula after the war than will the engineering colleges; that a reexamination of the curriculum is a desirable end whether the college be one of arts, science, or engineering seems obvious. The circumstances of the present moment will result, it is to be hoped, in a badly needed house-cleaning within the ivory towers of many previously sacrosanct citadels. The tradition of the liberal arts will be seriously interrupted by the war—the extent of the cleavage being in direct proportion to the length of the conflict. Even at present, the liberal arts tradition, as we have known it in the men's colleges, has been terminated despite the brave words of those college presidents who boast that they are keeping the flame of liberal arts alight in the breasts of their 4–F enrollees!

By contrast, the engineering curriculum is now undergoing far less change; the navy program will not alter our basic curricula to any great extent, so that unlike the arts colleges, we shall probably maintain a definite continuity throughout the war years. The army program, although it is much shorter, will nevertheless introduce trainees to technical education, which they may desire to pursue further after the war. Furthermore, since this is a technological war, it seems reasonable to assume that many other service men will want to expand their technical knowledge, acquired in wartime, in the post-war world. Finally, the thousands of engineering students who have left us in the middle of their college years will take up their studies again where they were left off—the chief motive probably being to secure a job. Any radical changes in engineering programs will hardly be welcomed by these would-be engineers; on the other hand, it is my feeling that radical changes to adapt the arts college's program to living in the present world would be welcomed by almost everyone except a benighted few whose minds are so deeply in bondage that the word "liberal" has a humorous or even ironic

*Presented at the 50th Anniversary Meeting (English), S.P.E.E., Chicago, June 18–20, 1943.

twist when applied to them. In summary then, I would suggest that our plans for post-war humanities be made on the assumption that we in the humanities must grow or remain static within the general pattern of an engineering curriculum that will remain basically unchanged. Three conditions seem to warrant this conclusion: first, our continuity of tradition through the war years; second, the large numbers of men who have had their first introduction to technology as it is applied in the armed forces and who will want to expand their knowledge of this field in the post-war world; third, the engineering students whose studies have been interrupted by the conflict but who will want to take up where they left off in order to acquire their engineering degrees.

If these assumptions are correct, we will not have the same opportunity as the arts colleges to begin afresh, to discard those things that are outmoded. It is, therefore, incumbent on us in the technical schools to utilize forethought and planning *now* to insure the growth of the humanities in the future. All of us here must look with grave concern on the present state of the liberal arts; our colleagues in the scientific and engineering departments are questioning, and will continue to question, the values which we represent just as the whole liberal arts structure is now being questioned. We must be prepared to answer these queries effectively lest we lose ground in the post-war educational organization.

I do not propose to defend the humanities before this group; for us they need no defense. Obvious to us is the fact that applied science must play a major role in any acceptable world order that emerges from the present struggle; but science does not operate in a vacuum. It is an integral part of the social order; it can function best when the technical and the social aspects of modern civilization go hand in hand; it cannot function adequately as a segregated specialty. If engineers are to take the most responsible posts in the post-war world, they must understand the social and cultural implications accompanying technological developments. We must continue to insist that the engineer have a thorough understanding of the social and cultural heritage of the human race. Many of us feel we have fallen far short of this ideal in the past; as we think of engineers in general, we are reminded of George Russell's comment on a renowned scientist: "He is not really intelligent for his mind embraces little outside his profession. A candle does not shine light only in one direction." This narrowness of outlook has always been the most serious indictment of the engineer; we as a group cannot escape a partial responsibility for this. Perhaps we have been too uninspiring or too busy to quicken in our students a lively interest in the various aspects of human culture which we represent. Over and above all else, we have had too little of the student's time to do our job effectively.

You will note that I have said "a *partial* responsibility" for this state of affairs belongs to us; this responsibility also rests squarely on the shoulders of the administrations under which "we live and move and have our being." A reading of past volumes of THE JOURNAL OF ENGINEERING EDUCATION reveals countless pious expressions of belief in the humanities by college presidents; yet an examination of the scope of humanities in the technical schools hardly shows that the adminis-

trators are willing to translate their words into action. "The gentlemen do protest too much, methinks."

I am inclined to view the organization of a college curriculum as a practical working out of power politics, with the courses representing compromises which reflect the personal views of those in power. The safest course for the executive, obviously, is to preserve the status quo; this keeps the alumni happy because their one desire is to keep the college the same as it was in their undergraduate days; the majority of the faculty are delighted because they view with alarm any tendency to change the rights and privileges which time has ripened into prerogatives; and the students, however much they may desire a change, hardly ever have a leadership sufficiently articulate to dent the aura of divine right in which a college presidency doth hedge itself! Only when a minority group like an English or a Social Studies Department becomes sufficiently vociferous is this delightful state of affairs altered—and even then, the chances are slight because we are usually overwhelmed by sheer weight of numbers. Just to make all this specific, I should like to refer to the numerous occasions when we in the humanities are urged by our colleagues in the engineering departments to coordinate our work with what goes on in electrical engineering or physics or chemistry. How enlightening to the English Department would be a term paper on "The Cathode Ray Oscillograph" or on "Phenol-Formaldehyde Plastics"! Perhaps we need such enlightenment; but many of us would feel much better if the electrical engineers, the physicists, the chemists were to show an equal interest in the work of the economics, history, or English departments. A reciprocal trade treaty to work should really be reciprocal; in the engineering colleges this reciprocity seems all too rare, chiefly because we in the humanities are the smaller nations which are expected to accept the terms dictated by the larger ones.

If this view of the organization of our colleges seems factual, then we in the humanities might as well be realistic about the mechanism by which we can advance in the future. We believe our cause is just, but we must convince a lot of other people of its justness before we can make progress —and by progress I mean more time to do a better job than we have been able to do. And now, during war time, we should begin our preparation for the future, unless we want to imitate "Rose of Washington Square" who "ain't got no future, but Oh! what a past!"

Let us proceed, then, to an examination of our possibilities of growth in the future. If our objective is to produce an engineer who can speak and write effectively, who has an acquaintance with the great productions of human culture, and who has some understanding of the historical and economic forces that shape modern civilization, it is apparent that we must be given more time to accomplish these ends. It may be an oversimplification, but I think it is true, that the college administration which believes sincerely in the humanities will be able to find time for them to be adequately taught. Our task is to show that this time can be used effectively by teachers who command the respect of administrators, faculty, and students.

We are in a fortunate position to do this, thanks to the investigations and surveys of the humanities which have been made in recent years. The re-

port of the Committee on English on "Instruction in English in Engineering Colleges," surveys such as Professor R. H. Rountree's "The Present Status of 'Non-Technical' Engineering Education in American Universities," and Professor A. M. Fountain's "A Study of Courses in Technical Writing," give a clear picture of our problems, our methods, and our weaknesses. In the post-war world, we should begin translating these recommendations into action. Our worst fault has been our failure to achieve action on the really excellent ideas that have been presented by these investigators. For years we have been saying "The humanities are good; therefore, we must have more of them." This merely begs the question; and college administrators have heard the statement so often that like the ticking of the clock on the mantel, it doesn't even penetrate their consciousness. Perhaps it is only the temerity of one who has been in the profession a comparatively short time that impels me to point out in the concluding part of this paper the items of our unfinished business—business which we must attend to if we would be judged by our actions rather than by our words.

Item one concerns the training of teachers for the humanities in engineering colleges. For the last dozen or more years, there has been violent criticism of the Ph.D. discipline as a preparation for a teaching career in the engineering college. We have discussed all sorts of methods by which we might train better teachers; yet, so far as I know, this has remained completely in the realm of discussion—is it not time that we try to act? Would not some graduate school lend a sympathetic ear to a course of graduate study recommended by such a group as this? Can we afford to let an opportunity of this sort go unheeded?

The second item involves the best plan for organizing the humanities within the engineering school. At the Michigan Conference, it was apparent that our interests were so diffuse as to make a common ground difficult. Some of us represented humanities departments, others English departments, speech departments, social studies departments, and so on. Perhaps there is strength in union; if so, we might achieve more lasting results if we were differently organized with all the humanities merged as a group headed by a dean of humanities. A thorough study of the possibilities of new types of organization might lead to making us a more effective political group within the college.

The third item would be the tackling of the problem of making careers in the humanities departments sufficiently attractive to induce promising young men to enter them. Report after report has demonstrated statistically that the instructor in the English, economics, or history department of the technical school teaches a heavier load than the comparable instructor in the arts college; writer after writer has pointed out the desirability of time for individual conferences with students. Can we not go on record to establish the maximum desirable load for the humanities instructor? This is certainly an important consideration in the mind of a young man who might join us in our career.

Fourth, is a need for a detailed study of the time that could be allotted to the humanities within the curriculum. Professor R. H. Rountree's report on "The Present Status of 'Non-Technical' Engineering Education in Amer-

ican Universities"* shows that "on the average engineering students . . . devote sixteen per cent of undergraduate time to 'non-technical' subjects, of which two-fifths is given to English and one-fifth to economics." The maximum assignment of time to non-technical work is twenty-seven per cent; the minimum is zero. None of us in the humanities departments would agree that sixteen per cent of the student's time is enough to train him to speak and write with proficiency, to acquaint him with literature, history, and economics; and even in this sixteen per cent there are many courses that look ill at ease under the title of "non-technical." But sixteen per cent of the student's time is the average portion that forty administrations have allotted to us, and if we hope for better things, we must work to obtain them. We have been like infant industries, protected by more or less benign administrators in our endeavors; but the industry which grows up and justifies itself is the one to invest in.

Our great chance for growth in the future, it seems to me, lies in the field of electives (or general studies, or non-technical options, as they are called in various schools). We cannot really expect to have a much larger claim staked out for us than a required two-year sequence in language and literature and another two-year sequence in history and economics. Beyond that, we must justify ourselves at every step; the one principle that we can rightly insist on is that if electives in the humanities are set up, they must really belong in the humanities. There are some strange new arrivals registered in our academic books as "general studies"; I am not the hotel detective, but if I were, I should keep a sharp watch on certain of these newcomers, for they appear to me to be highly suspicious characters. This English group might well assume the role of house detective by defining what properly belongs in the province of the humanities and by attempting to eject these masquerading guests.

Finally, as a corollary, we need a more clear-cut formulation of our own objectives than we have ever had before. We are expected to do in a comparatively short time what many an arts college has failed to do in four full years; this fact makes it even more imperative that we know exactly what our goals are, for we have no time to waste in fruitless efforts. Probably the best that we can hope for from the products of engineering education are men who will be supporters of the arts, drama, music, and literature; the job of sizing up what is good and of shaping critical judgment in cultural realms, we can leave to the arts colleges. I should like to see engineers represented on the boards of trustees of our playhouses, our art museums, and our libraries, as well as on our chambers of commerce and civic welfare agencies. This is certainly not too much for us to hope. In addition, we can rightly expect our engineering graduates to understand the impact that science has had on human institutions. Alexander Meiklejohn has said: "Many causes have produced the present World War. But high among them all is the failure of our Anglo-American institutions of liberal learning. It is not the forces of the modern world which have wrecked us. It is our lack of understanding of these forces." We in the engineering colleges cannot escape our share in this failure;

*The Journal of Engineering Education, November, 1941.

and in the future, we must try to correct past mistakes.

In summary, the status of the humanities in the post-war engineering college presents a definite challenge to this group. If we grow, we shall probably do so within the pattern of present curriculum; because of the premium the war has placed on technology, our colleagues in the engineering departments will undoubtedly be more smug than ever about the importance of technical subjects, and consequently less ready to concede time to the humanities. To meet these conditions, we must first set our own house in order and present a solid front in the future.

Perhaps the most realistic approach to these problems would be the formation of a committee to represent this group and to present our objectives and our problems before the administrative group of the Society for the Promotion of Engineering Education at some future session. At the moment, presidents and deans are so beset with the immediate questions of their relations with the army and navy that they can give little thought to long range planning; but sooner or later, they will turn their attention to fundamentals. When they do, we should be ready with answers to such questions as the following:

1. Would we in this group achieve a greater solidarity by inviting members of economics, speech, history, social studies, and other similar departments to join us?
2. Can we define our objectives so clearly that we can go to our administrations with a direct statement of what we hope to accomplish and a reasonable estimate of the time needed to do it?
3. Is it possible, or desirable, to make recommendations concerning the most suitable graduate training for young instructors in our departments?
4. Can we define what should be included in "the humanities" so that we have a criterion for ejecting a few of the dubious courses that are so labeled?

Such a committee, when it finally reported to the administrators, would at the very least serve to educate a few college presidents and deans to our viewpoint. Furthermore, it would carry our message to those in the top of the college hierarchy.

When all else is said, we represent the oldest, the most respected tradition in the engineering school; compared to the humanistic values and cultural heritage in which we believe, applied science is but an infant, albeit a lusty one. It is our task to see that engineers do not lose sight of these human values in spite of their pre-occupation with bigger and better plastics, electric eyes, and radio detection devices. If we do this with enthusiasm, courage, and foresight, we cannot fail.

Training for Production Engineering in the Aircraft Industries*

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Even before war broke out, manufacturing industries were called upon to produce material far above their normal peacetime capacities, and it was soon realized that peacetime manpower supply methods would no longer be sufficient. This was found to be especially true in the field of aircraft production. In this industry, as never before, wartime conditions accelerated its activity, and with this acceleration came demands for trained aeronautical engineers and other technical personnel. Production in the aircraft industry was an entirely new thing. Before the war, assembly line methods of aircraft production were unknown. The problems of putting into effect a large scale program of aircraft production were enormous, since few manufacturing methods could be adapted from those used in other older mass production industries. Materials, installed equipment, wiring, furnishings, armament, and a thousand other things were entirely new to any production program. Furthermore, large scale manufacturing was entirely new to Texas. Many production problems presented themselves and in order to supply the necessary personnel to solve these problems, it was soon realized that educational programs must likewise be accelerated.

The first attempts to satisfy industrial aircraft production training requirements by The University of Texas, beyond the scope of its regular engineering program, were made through coöperation with the United States Office of Education and its Engineering Defense Training Program. In February, 1941, an intensive full-time (36 hours per week for 15 weeks) aeronautical engineering course was organized on the University campus in Austin. The prime purpose of this course was to convert other types of engineers, such as civil, mechanical, petroleum and chemical, to aeronautical engineering work in a minimum time. A condensed outline of the content of this course is shown in Table I. The course was largely a condensation of a standard college level aeronautical engineering curriculum with some special attention being given to meet the needs of industry for men who would be immediately productive on comple-

* Presented at the 50th Anniversary Meeting, S. P. E. E. (Aeronautical), Chicago, June 18–20, 1943.

tion of their training.* The work in aircraft engines was presented primarily from the standpoint of performance and its relation to the rest of the airplane so that the course was basically one for airframe engineers and not for aircraft engine designers.

TABLE I

OUTLINE OF FULL-TIME E. D. T. COURSE IN AERONAUTICAL ENGINEERING AT THE UNIVERSITY OF TEXAS

Subject	Hours Per Week	
	Lec.-Rec.	Lab.
1. Elementary Aerodynamics	3	0
2. Elementary Aircraft Structures and Stress Analysis	3	0
3. Aircraft Engines, Propellers and Instruments	2	0
4. Aircraft Materials and Processes	2	4
5. Machine Shop and Welding Practices	3	6
6. Aircraft Drafting and Detail Design	3	10
Total Hours Per Week	16	20

Students registering for this course consisted of three major groups:

1. Those who had not been able to complete engineering college work begun in the depression years.
2. Those who had acquired engineering education and experience in other fields, but who wished to transfer to aeronautics because of decreased activity in their original field.
3. Engineering students previously enrolled in college who did not wish to spend the longer period of time required to complete their regular course leading to Bachelor's degree.

Requirements for entrance were approximately the equivalent in education and experience of junior standing in engineering college work. Hence it is not surprising that, during the two years this course was in operation, only one woman student enrolled in it and successfully completed the work.

No attempt was made to satisfy the training requirements of any specific manufacturing firm although close contacts and much valuable information were obtained from most of the larger aircraft companies. If a student obtained employment before the end of the course, some effort was made to acquaint him with the engineering procedures, drafting room manual, and standards of his future employer. This practice is now an integral part of the regular University courses in aircraft design.

This full-time training program in Austin was repeated continuously for a total of six courses under E. D. T., E. S. M. D. T., and E. S. M. W. T. sponsorship, the last course ending in February, 1943. The history of the course is particularly interesting in that it shows a significant trend in the availability of qualified engineering personnel. At the beginning of the program, relatively little difficulty was experienced in obtaining satisfactory enrollments. This situation prevailed until the spring of 1942, at which time it became increasingly difficult to find students properly qualified for this training. In spite of the fact that the aircraft industries had found the graduates of previous courses to be highly satisfactory and continued to express a heavy demand for additional

* Thompson, M. J.: "Evolution of Aeronautical Engineering Education," JOUR. ENGR. EDUC., Vol. XXXII, No. 4, Dec., 1941.

trainees, the decreased potential supply of qualified students made it evident that this course could no longer be profitably continued. For this reason the course was not repeated following the completion of the last class in February, 1943.

Some indication of the success of this course may be obtained from employment records of the students who have taken it. They are now employed in the engineering departments of practically every major aircraft plant in the United States. The few men who have gone into the Armed Forces are in most cases engaged in work in which this training has been of considerable value to them.

TABLE II

EFFECTIVENESS OF TRAINING OF THE UNIVERSITY OF TEXAS E. S. M. W. T. COURSES IN AERONAUTICAL ENGINEERING

Course	Number Enrolled	Number Completions	Number Employed in Aircraft Industry	Number in Armed Forces
1	18	14	15	3
2	12	12	10	0
3	10	10	9	1
4	20	18	18	2
5	10	10	9	0
6	6	6	4	0
Totals	76	70	65	6

In Table II there are given a few pertinent statistics on this course covering enrollment, number of completions, number employed in the aircraft industry, and number in the Armed Forces as of April, 1943.

In the autumn of 1941, field activities in the form of short courses which it was hoped would satisfy the specific, immediate needs of the Texas aircraft industries were undertaken. Part-time training courses under the E. D. T. program were first set up in the Fort Worth-Dallas area in September, 1941, at which time two courses were organized. From this small beginning, the Fort Worth-Dallas program has expanded so that it now includes some 25 different courses with a total of approximately 35 sections.

Early wartime training for the two major Texas aircraft firms, Consolidated Vultee Aircraft Corporation in Fort Worth and North American Aviation, Inc., in Dallas, was, by present day standards, relatively ineffective in meeting industrial requirements. In those early days Texas aircraft industries were in their infancy and were as inexperienced in determining their needs as the training agencies were in satisfying them. Courses set up were rather general in character and did not have any particular, immediate industrial use. For example, courses in aircraft materials and processes, aircraft drafting and general types of inspection courses were given, which could only be classified as supplementary training. Neither Consolidated Vultee nor North American had any more than a skeleton crew of draftsmen at that time, but the drafting course was considered valuable in supplying aircraft personnel with a broader background.

Gradually industry and education unified their ideas. Supplementary courses definitely began to satisfy immediate needs intended. Industry and training were finally getting together. A 'preëmployment program was soon launched in an attempt to provide industry with adequately trained technical personnel. This program never reached the size anticipated by most for the reason that the bulk of such training was needed for shop person-

nel on the vocational level. It was found that only a few technical supervisory men were needed at that time. Thus this program had an extremely limited scope. During this early period, the place of college level aircraft training activities in the whole training picture was not very clear. Texas firms were then intended to be assembly plants with only skeleton crews of supervisory personnel. All engineering and production planning was to be done elsewhere.

However, during the late summer of 1942, the picture at Consolidated Vultee changed greatly. Their plant became a complete organization from stem to stern. It included every phase of aircraft production and engineering of new airplanes. North American soon followed suit but their metamorphosis was not so abrupt, and did not involve The University of Texas program as much as it did that of other educational institutions. The period after these changes might be called "Phase II" of the college level aircraft industrial training program.

The University's field activities in North Texas were thereafter largely devoted to aiding Consolidated Vultee during this transition. The problems involved in converting this great plant from one type of organization to an entirely different type were enormous, especially in view of the fact that other industries and the Armed Forces had already almost completely absorbed the available supply of engineers and other supervisory men now so badly needed at Consolidated Vultee.

In general, three types of courses are offered in the present program which represents Phase II in fairly full development.

1. *Preëmployment.*—Part-time training, usually given two evenings per week outside of working hours, in which instruction is given to relatively inexperienced personnel for subsequent employment in a specific technical position.
2. *Supplementary.*—Part-time training outside of working hours in which instruction is given along the line of the student's full-time work in war production. A term used by industry for a similar type of training is "up-grading," which differs only in the location of the class. Up-grading courses use factory facilities, laboratories and class rooms.
3. *In-service.*—Full-time (40-hour week) training, similar to preëmployment training in satisfying an immediate employment problem, except that students are actually engineering apprentices on the payroll of the firm involved. The aircraft industry calls this "prefactory training."

Preëmployment training, like the full-time Austin program, was at first fairly successful but fell by the wayside when demands of other industries and of the Armed Forces made satisfactory enrollees practically non-existant.

At the present time, preëmployment work has been almost entirely replaced by in-service courses which accomplish the same purpose in a more effective way. A great many problems have risen out of the in-service type of course. Recruiting of suitable employees has been one of the major concerns. Many people apply for this training, yet few are qualified. In order to determine a student's adaptability for the work in which he is to be trained, informal and brief aptitude

tests have been established and every applicant is carefully interviewed by the University's supervisory staff, the company's employment office and frequently by the instructor.

Another problem of in-service training has been the coördination of the course material with industrial requirements so that it will produce the desired quality of employee. This is largely dependent on the instructor's ability and on the care used in planning the course. It has been found that the success of in-service training depends almost entirely on the instructor's ability, not only in the presentation of classroom instruction, but principally in the coördination of his instruction with the knowledge required on the job. The college supervisor cannot know all the intricacies of industrial requirements. Even industrial training directors are occasionally vague in formulating and expressing their ideas of their own company requirements. The success of this program is consequently greatly dependent upon the instructor's familiarity with his subject as applied to his company's operations.

Instructors very frequently are long on technical ability and short on instructional ability. It has been found, however, that it is infinitely better to train a technical man to be an instructor rather than try to make a technical instructor out of a man trained in pedagogy alone, when the latter is not too familiar with the course material. An extensive instructor-training program has never been set up, principally because it was felt that the results obtained from present methods are satisfactory. Furthermore, practically all instructors are plant engineers and hence do not have much time available for any formal teacher-training. Most instructors fall almost automatically into what might be called adequate teaching methods, once they face their class. Though some instructors are extremely "green," they, almost to a man, have acquired from technical and practical experience, the same psychological fundamentals and their practical application which an elaborate instructor-training program would provide. It has only been necessary to provide occasional informal suggestions and corrections regarding instructional methods and this is readily accomplished through fairly close supervision and guidance of the actual class work.

The problems of supplementary training are quite similar to those of in-service training. However, supplementary training involves a great number of separate and distinct courses of greatly varying types, while in-service training has so far been along two closely related lines—engineering drafting and engineering lofting. Approximately 20 different types of supplementary courses are offered, each requiring a special and different technique in coördinating course material with industrial requirements. Here again, the instructor is all-important as the representative of industry in the type of training for which he is giving instruction.

A great deal of difficulty has been encountered in regard to text material. In only a very few cases have there been adequate texts for the courses offered, largely due to the fact that supplementary training is needed in so many highly specialized lines for which little material has ever been published. Here again the instructor is the key man in preparing text material wherever possible.

In Table III statistics are shown on

the activities of The University of Texas E. S. M. W. T. program during the period from July 1, 1942 to April 15, 1943. The type of course is indicated in this table by the following code; P—Preëmployment, S—Supplementary, I—In-service. Enrollment figures show the maximum number enrolled in the course, the number who completed the training, and the number who were employed or promoted as a result of such training. The latter figures have been supplied by the Consolidated Vultee Aircraft Corporation and by North American Aviation, Inc., which were the principal companies served by this program.

A highly significant point brought out in Table III is the rather low number of student completions found in the

TABLE III

EFFECTIVENESS OF TRAINING OF THE UNIVERSITY OF TEXAS E. S. M. W. T. PROGRAM IN AERONAUTICAL ENGINEERING IN THE FORT WORTH–DALLAS AREA

Title	Code No.	Type	Number Sections	Maximum Enrollment	Number Completions	Number Employed or Promoted
Aircraft Drafting and Math	011	P	6	121	37	31
Aircraft Drafting and Math	123	P	2	64	25	9
Advanced Aircraft Dftg	010	S	2	50	20	10
Aircraft Drafting for In-Service Employees	095	I	2	50	49	49
Aircraft Drafting for In-Service Employees	122	I	2	49	46	46
Aircraft Drafting for In-Service Employees	135	I	2	56	52	52
Aircraft Template Dev	005	P	3	105	73	56
Aircraft Template Dev	064	P	4	100	53	40
Aircraft Lofting	004	S	2	75	41	10
Aircraft Lofting	047	S	1	33	15	9
Aircraft Lofting	062	S	2	60	31	19
Aircraft Lofting	110	S	1	41	21	16
Aircraft Lofting for In-Service Employees	111	I	1	25	21	21
Aircraft Lofting for In-Service Employees	136	I	1	25	19	19
Aircraft Elec. Systems	028	S	4	134	79	20
Aircraft Elec. Systems	087	S	2	54	21	10
Aircraft Elec. Systems	116	S	1	22	9	3
Elements of Aircraft Hydraulics	068	S	1	32	5	2
Small Tools in Aircraft	037	I	1	40	22	8
Aircraft Materials and Fabrication Processes	019	S	1	30	17	11
Aircraft Instruments	018	S	2	98	48	16
Aircraft Instruments	091	S	1	38	15	7
Elementary Aerodynamics	034	S	1	15	12	4
Basic Math. for Aero. Engrs	076	S	1	15	6	1
Aircraft Descriptive Geom	075	S	1	18	8	3
Aircraft Communication Systems	085	S	1	34	14	14
Wood Technology in Aircraft	096	S	1	21	8	3
Inspection of Aircraft Elec. Systems	017	S	1	13	4	4
Inspection of Aircraft Hyd. Systems	030	S	1	19	7	6
Aircraft Tool Planning	002	S	2	49	33	10
Inspection of Aircraft Materials and Parts	012	S	2	41	11	4
Aircraft Flight Inspection	089	S	1	22	8	4
Totals			56	1,549	830	517

TABLE IV

THE UNIVERSITY OF TEXAS E. S. M. W. T. PROGRAM IN AERONAUTICAL ENGINEERING
COURSES NOW IN PROGRESS

Title	Code No.	Type	Number Sections	Maximum Enrollment
Fundamentals of Aircraft Drafting	175	P	3	27
Advanced Aircraft Drafting	137	S	3	77
Aircraft Drafting for In-Service Employees	135	I	1	56
Aircraft Drafting for Student Employees	195	I	2	49
Aircraft Template Development	148	S	3	82
Aircraft Lines Lofting	164	S	1	22
Advanced Aircraft Lofting	162	S	1	30
Aircraft Lofting for Student-Employees	177	S	1	25
Aircraft Electrical Systems	163	S	2	
Aircraft Hydraulic Systems	109	S	1	12
Aircraft Instruments	155	S	1	28
Elementary Aerodynamics	117	S	1	24
Basic Math. for Aero. Engrs.	167	S	1	27
Liaison Engineering Practices in Aircraft Industries	168	S	1	29
Engineering Planning and Scheduling in Aircraft Industries	151	S	1	20
Aircraft Engines	108	S	1	38
Aircraft Flight Inspection for In-Service Employees	147	I	2	31
Thermodynamics for Aeronautical Engineers	173	S	1	12
Totals			27	589

case of many of the preëmployment courses as compared with the other types of training. Experience has shown that this is definitely not due to poor instruction, but rather to the lack of staying power on the part of the student and the many other immediate calls for both voluntary and compulsory service from other industries and the Armed Forces.

Table IV gives a summary of The University of Texas War Training Program in operation in the Fort Worth-Dallas area on April 15, 1943. The complete replacement of preëmployment courses by the in-service and supplementary types will be immediately noted. Figures on maximum enrollment are given in this table but, of course, complete information on employment and promotion of students is not yet available.

Another type of war training program in which the University of Texas is participating is essentially an extension over a larger time scale of the E. S. M. W. T. in-service type of course. This is exemplified by the Curtiss-Wright Engineering Cadette program, now in operation for a ten-month period, during which instruction in the fundamentals of aeronautical engineering is provided for a relatively large but carefully selected group of college women. The average Cadette has had approximately two years of college work before entering this program and in many cases, had had considerable work in mathematics and science. On completing the program she is to be employed in the Engineering Department of one of the Curtiss-Wright plants. While Curtiss-Wright has been the pioneer in organizing this

type of training, it is understood that other companies, such as R. C. A., Hamilton Standard Propellers and the Pratt and Whitney Aircraft Engine Division of the United Aircraft Corporation, have recently set up similar programs, and numerous others are about to follow suit.

While the University's participation in the Curtiss-Wright program has brought up many new and interesting problems, it is too early to make any definite statements regarding the effectiveness of this type of training. Much careful planning on the part of Curtiss-Wright and the seven engineering schools coöperating, has gone into the development of this program. The Cadettes, as a whole, have shown a willingness to work and a sustained enthusiasm which augurs well for the final outcome.

This program is particularly interesting as an educational experiment because of its much greater length than any other types of in-service war training courses and the unusually close cooperation between industry and education which has existed throughout its development. A third aspect of the experiment is the bringing of women into the engineering field which heretofore has been held by many to be man's sacred domain. It is interesting to speculate on this latter point and its effect on post-war engineering training and practice.

The development of the various phases of the war training program has certainly built up a closer coöperation between industry and the University than has ever existed in the past and it is hoped that the benefits of this coöperation may be carried over into the post-war period. The immediate purpose of the program has of course been one of getting the training job done as quickly and as effectively as possible but there is much that should come out of these experiences which will be of lasting benefit to both industry and education.

It is more difficult to predict specific trends in aeronautical engineering education as they may influence the post-war picture because no one knows what the industrial picture itself will look like at that time. If definite answers were available to the following questions, then speculation as to the future could be fairly accurate:

1. Will the post-war aircraft industry continue to develop on a mass production basis?
2. What are the post-war demands for flivver planes and helicopters likely to be?
3. How rapidly will our commercial air transport systems expand and what kind of equipment will they use?

Any genuine aviation enthusiast can paint a glowing picture yet withal a sensible one for the future of aviation but at present this can certainly be only qualitative. For these reasons it would seem that it is particularly important that education should strive to maintain and increase the close contacts with industry developed during the war period. Education must remain sufficiently fluid and adaptable to meet rapidly changing industrial requirements. If this is not done, education may find itself facing a severe case of "technological unemployment."

On the other hand, education must always strive to serve as a balance wheel in the engineering training process which, after all, only begins in the educational institution. College programs should certainly not attempt to follow every changing pattern of de-

tail and style which may exist in industry at the moment but rather should insist on a building up in the student of a firm foundation in the fundamentals of mathematics, chemistry and physics. The question of how far to go with specialization in undergraduate work will always be a difficult one but can only be answered by carefully balancing the need for a thorough coverage of fundamentals and the limitations of time against the desire of the student for *specific* knowledge about his chosen field and the need of industry for an engineering graduate who can be made immediately productive without too long a "breaking in" period.

As to specific ways in which this cooperation might be continued, it is hoped that frequent round-table discussions will become a regular practice as they have been in war training activities. Interchange of ideas between engineering instructors and industrial engineers should not only be maintained but a temporary exchange of personnel also has many advantages to recommend it for serious consideration. If this can be worked out on a more systematic and formal basis than by merely having instructors work in the plants during summer vacations (which are now non-existent!), it should do much to aid engineering education in improving its product. It is understood that some aircraft companies are already giving serious consideration to such a plan.

Whatever may be the nature of aeronautical engineering programs in the post-war period, it is hoped that education and industry may continue to follow the war-time policy of sitting down at a table and trying to work out together the best ways of training the engineers who must rebuild the world of tomorrow.

The Curriculum in Engineering Physics at the University of Maine*

By C. E. BENNETT

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The function of the present paper is, as I understand it, to start off this symposium on Curricula Leading to Degrees in Engineering Physics by telling you what has been accomplished at the University of Maine since 1937 when its curriculum in engineering physics was conceived. This was before the days of A.S.T.P. At that time physics was not enjoying the same popularity that it does today. The Physics Department of the University of Maine, administered in the College of Arts and Sciences, had practically no major students. Probably 95 per cent or more of its work was service work for the College of Technology, including the freshman course in college physics, which was, and still is, an important part of the first year's program common to all of the Technology curricula. This was about the time when the American Institute of Physics was attempting to stimulate interest in "Applied Physics" following a highly successful conference in New York City in the Fall of 1936. Many will recall the very significant report published soon afterwards by the A.A.P.T. Committee.

Several students in our elementary course found themselves unable to elect more physics than the first course because of limitations imposed upon electives by the specialized requirements of the various Technology curricula. Indeed, a tendency toward over-specialization in the various traditional fields of engineering is, in my opinion, one of the strongest arguments we have in favor of engineering physics. In this instance an opportunity arose to suggest to the administration of the University a new curriculum, offering to give what certain selected and serious students wanted, namely, a more general type of engineering course, one based more upon fundamental science and mathematics than the conventional ones. Incidentally, the prospect of making the Physics Department more useful generally to the whole University was not to be overlooked.

Our proposals, incorporating specific recommendations of the American Institute of Physics as well as those of friends in industry, were approved by the University and the new curriculum called engineering physics was instituted under the auspices of the College of Technology in the Spring of 1938. The plan called for the closest possible coöperation between the deans of the two colleges concerned and the Department of Physics. I am happy to report that this close coöperation still continues and the

* Presented at the 50th Anniversary Meeting, S. P. E. E. (Physics), June 19–22, 1943, Chicago, Ill.

arrangement, crossing college lines as it does, has nevertheless proved very satisfactory. I quite agree with a remark once made by Professor Bidwell of Leigh University that such a curriculum must be administered under the auspices of the College of Technology. I do not believe that it can develop successfully in an Arts and Science college if, in the same university, there is a College of Technology.

Since the inauguration of the program, from eight to fifteen students per year have started the sophomore work in this curriculum. Six of the first class graduated two years ago, and, except for the two who went directly into the Army via advanced R.O.T.C., they found immediate employment. Needless to say, the men this year received numerous offers apiece. In this respect also, we find, as has been discovered at Lehigh and other places, that, in general, the men are good students and are eagerly sought by industry.

In this connection it is lamentable to note that five of our next group of seniors have been taken from us by the Army for no other reason than that they were in advanced R.O.T.C. They are not being allowed to complete their senior year, which act would, I feel sure, make them far more valuable to the country in the war effort. Furthermore, five of our incoming juniors, including the best student in the class, have been called into the Army via the Enlisted Reserve Corps. On the other hand, the incoming sophomore class numbers eleven, which represents a very much larger percentage of the present reduced registration of the college, and indicates the ever increasing interest in the curriculum.

Although the recent physics registration for the summer term was very gratifying, the question is nevertheless raised as to whether or not the curriculum, important as it seems to be in this "physicists'" war, will be able to survive. It is necessarily a small group, only thirty to forty students at one time, and it can easily be wiped out by the unwise dissipation of the few physics students available before they have completed their undergraduate work. On the other hand, relatively few colleges and universities have more physics majors than this and it may be hoped that the Army will include every institution with an engineering physics curriculum in its advanced A.S.T. Program.

As to the content of the curriculum, our desire was to incorporate such courses as would provide a basic program in engineering science, *i.e.*, physics, mathematics and chemistry, and then to provide each student with the opportunity and obligation to elect, under our supervision, such traditional engineering courses as would enable him to work up a strong minor in one or more branches of engineering. Schedule complications dictated some of the choices and general college requirements such as junior year mechanics (engineering), public speaking, and second year English accounted for others. We also deliberately included machine tool laboratory because it was strongly recommended by our friends in industry.

We have tried to overcome a common criticism, which we think deserving, that physics courses are often too abstract. Physics teachers are sometimes more concerned with the derivation of a certain relationship

than with the significance of the result once it is obtained. We have also tried to overcome an objection which has justly or unjustly been levelled at "General Engineering," that it prepares for "nothing in particular." We virtually require, in addition to the specialization in engineering science, the development of a strong minor in something else. But above all, we try to keep in mind the fact that our students are *engineering students*, not students attracted away from engineering and drawn into pure science. We believe we are making better engineers out of this relatively small selected group by emphasizing the science behind engineering and postponing some of the specialization in college years. We further believe that this program makes them more adaptable to their first job. We feel that no one can predict exactly what their first job will be, and so we cannot prepare specifically for it.

The physics courses in the curriculum start with intermediate general physics supplemented by laboratory work. This course was described at the Pennsylvania State College meeting of this Society (June 1939) and is written up in the JOURNAL OF ENGINEERING EDUCATION (Vol. XXX, No. 8, April 1940). This course not only reviews the topics of the first-year course—and it is my opinion that most physics teachers definitely underestimate the need for such a course, relying too much on the ability of the average student to master general physics in one year—but supplements the material by a more mathematical presentation to a smaller and more interested group. This prepares the way for advanced courses, which in our plan are one-semester courses. We believe that the advanced college physics courses should take the student fairly well through most of the conventional fields of physics and should not be limited to one or two fields even if these can be much more completely covered by so doing. In other words, we appeal for more single-semester advanced courses instead of a few whole-year courses, and wish more textbooks were written for semester courses.

The curriculum for the last two years is really a skeleton curriculum comprising at least one basic classroom physics course during each of the four semesters and supplemented by numerous electives. The four classroom courses which we consider basic are electricity and magnetism, practical optics (Hardy and Perrin), modern physics and thermodynamics. In addition to these classroom courses we require an advanced laboratory course in electrical measurements, and senior laboratory. The second semester of the latter course has, until this year, been a senior thesis course in which some project is worked up. Due to the difficulty in getting materials and equipment, however, thesis work has been supplanted for the duration by a second semester of advanced laboratory. Certain electives in physics are also approved. The course in electronic phenomena, incidentally, which has been offered in alternate years might just as well be considered a requirement in view of its present popularity. Courses in sound and mathematical physics have also been given in the recent past.

A detailed list of the courses in the curriculum follows:

UNIVERSITY OF MAINE

CURRICULUM IN ENGINEERING PHYSICS

Leading to the Degree of Bachelor of Science in Engineering Physics in the College of Technology

(Revised July 1943)

This curriculum is an answer to the growing demand on the part of industry for college men trained in physics in an engineering atmosphere. It recognizes the fact that for certain students undergraduate specialization in a single engineering field is not a rigid requirement for success in industrial work. This program is basically one of applied science supplemented by a strong minor in one or more of the well defined engineering fields. It is developed around a framework of required courses in intermediate and advanced physics, mathematics, and chemistry in addition to certain strictly engineering courses, some required and some elected in the last two years. Thus the emphasis is placed upon both engineering and physics.

The curriculum is also suited for those students who, by virtue of their ability and interest, are preparing to do graduate work.

FRESHMAN YEAR

Fall Semester

Subject			Hours Rec. or Comp.	Lab. Cr.	
Ch	1	Gen Chemistry	2	4	4
Eh	1	Freshman Comp.	3	0	3
Md	1	Funds. Draft	0	4	2
Ms	1	Trigonometry	2	0	2
Ms	3	Algebra	2	0	2
Mt	1	Military	2	1	1½
Ps	1b	General Physics	4	2	5
Pt	1	Phys. Education	0	2	0
Gc	5	Orientation	1	0	½
					20

Spring Semester

Subject			Hours Rec. or Comp.	Lab. Cr.	
Ch	2	Gen. Chemistry	2	4	4
Eh	2	Freshman Comp.	3	0	3
Md	2	Ely. Mach. Draft	0	4	2
Ms	6	Anal. Geom.	4	0	4
Mt	2	Military	2	1	1½
Ps	2b	General Physics	4	2	5
Pt	2	Phy. Education	0	2	0
Gc	6	Orientation	1	0	½
					20

SOPHOMORE YEAR

Fall Semester

Subject			Hours Rec. or Comp.	Lab. Cr.	
*Es	1b	Prin. of Econ.	2	0	2
*Gm	19	German for Chemists	3	0	3
Me	9	Machine Tool Lab.	0	4½	1½
Ms	7	Diff. Calculus	5	0	5
Mt	3	Military	2	1	2
Ps	17	Intermed. Physics	3	2	4
Pt	3	Phys. Educ.	0	2	0
Sh	1	Pub. Speaking	2	0	2
					19½

* Suggestions for Electives

As	15	Gen. Astronomy	3	0	3
Md	3	Des. Geometry	0	6	2

Spring Semester

Subject			Hours Rec. or Comp.	Lab. Cr.	
Ch	40a	Quant. Anal.	1	6	3
*Es	2b	Prin. of Econ.	2	0	2
*Gm	20	German for Chemists	3	0	3
Me	10	Machine Tool Lab.	0	4½	1½
Ms	8	Int. Calculus	5	0	5
Mt	4	Military	2	1	2
Ps	18	Intermed. Physics	3	2	4
Pt	4	Phy. Education	0	2	0
					20½

* Suggestions for Electives

Ps	10	Meteorology	3	0	3
Ps	32	Photography	2	2	3

* Substitution may be made for courses marked * or they may be postponed with the approval of the department head. The student who may continue with graduate work is strongly advised to take at least one year of German. If Ee 1p, 2p is elected, it should be followed by Ee 15, 16 instead of Ee 35, 36.

Junior Year

Subject			Hours Lab.	Rec. or Cr.	Comp.
*Ch	71	Phys. Chem. or	2	6	(5).
*Ee	1p	Els. Elec. Eng.	2	3	3
Eh	5	Tech. Comp.	2	0	2
*Gm	21	German for Chemists	3	0	3
Me	53	Mechanics	3	0	3
Ms	57	Eng. Math.	3	0	3
Ps	53	Elec. Meas.	0	4	2
Ps	55	Elec. and Mag.	3	0	3

Additional Suggestions for Electives

ChE	33	Elem. Stoichiometry	3	0	3
Me	21	Mats. of Eng.	2	0	2
Me	41	Mech. Laboratory	0	3	1½
Me	43	Heat Engineering	3	0	3
Py	1	Gen. Psychology	2	2	3

Subject			Hours Lab.	Rec. or Cr.	Comp.
Ch	72a	Phys. Chem. or	2	2	(3)
*Ee	2p	Els. Elec. Eng.	2	3	3
Ch	84	Metallurgy	3	0	3
Eh	10	Modern Lit.	2	0	2
*Gm	22	German for Chemists	3	0	3
Me	54	Mechanics	3	0	3
Ms	58	Eng. Math.	3	0	3
Ps	72	Optics	3	0	3

Additional Suggestions for Electives

Ce	2	Plane Surveying	1½	½	2
Me	22	Els. of Mech. Eng.	2	3	3½
Me	44	Heat Engineering	3	0	3
Me	46	Heat Power	3	0	3
Py	2	General Psychology	2	2	3

Senior Year

Fall Semester

Subject			Hours Lab.	Rec. or Cr.	Comp.
*Ch	51a	Organic Chem.	3	0	3
*Ee	35	D.C. Mach.	2	0	2
Ps	69	Mod. Physics	3	0	3
Ps	81	Adv. Lab. Phys.	Ar		3
		Electives			6

Additional Suggestions for Electives

Ce	35	Hydraulics	2	0	2
ChE	75	Els. of Chem. Eng.	3	0	3
ChE	81	Chem. Eng. Lab.	1	4	3
Ee	13	Electronics	2	3	3
Ee	15	Elec. Cir. and Mach.	3	0	3
Ee	17	Elec. Lab.	1	3	2½
Ps	59	Sound	3	0	3
Ps	61	Adv. Meteorology	3	0	3

Subject			Hours Lab.	Rec. or Cr.	Comp.
*Ee	36	Alt. Current and	2	0	1
*Ee	38	Electrical Lab.	0	3	1½
Ps	50	Problems (Thesis)	Ar		3
Ps	62	Heat and Thermodynamics	3	0	3
*Ps	82	Adv. Lab. Phys.	Ar		3
Ps	98	Seminar	Ar		1
		Electives			9

Additional Suggestions for Electives

ChE	76	Els. of Chem. Eng.	3	0	3
ChE	82	Chem. Eng. Lab.	1	4	3
Ee	16	Elec. Cir. and Mach.	3	3	4
Ee	18	Elec. Lab.	1	3	2½
Me	92	Aerodynamics	3	0	3
Ms	56	Vector Anal.	3	0	3
Ps	58	Math. Physics	3	0	3
Ps	66	Electronic and Thermionic Phenomena	3	0	3

A total of 143 semester hours exclusive of Military Training 1, 2, 3 and 4 and Physical Training is required for graduation in the College of Technology. The above courses in Drawing, English, Public Speaking, and Military Science also comply with college requirements.

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* Substitution may be made for courses marked * or they may be postponed with the approval of the department head. The student who may continue with graduate work is strongly advised to take at least one year of German. If Ee 1p, 2p is elected, it should be followed by Ee 15, 16 instead of Ee 35, 36.

It is to be noted that most of the elective courses in the curriculum are strictly engineering courses. Thus the curriculum might well be called engineering and physics, because the physics courses are for the most part very similar to those ordinarily to be found in college physics programs. It really is engineering and physics. This emphasizes a point already made, that the students are engineering students. I am convinced that unless the engineering aspect of the program is kept constantly before the student, no such program as this will survive. It is my further observation that even in the advanced courses the so-called practical topics are of more interest to these students than the more abstract ones. In fact, I am not at all sure but that the course in modern physics, ordinarily thought of by physics instructors to be the course most likely to interest the student, may actually be the least interesting to some of these students.

I think it can be readily appreciated that one of the problems is the matter of student schedules, but since most of the engineering courses are usually scheduled fairly rigidly, it is quite possible by careful planning on our part to get all the physics courses in. One feature which has undoubtedly contributed to the success of the program so far is the fact that each student's entire course program is worked out by personal conferences with a single adviser, the department head, who handles all the registration details. Although this is time-consuming, it has the advantage of keeping him very close to the students and that is exceedingly important. The problem here is, of course, that of working up for each individual student the engineering minor which is largely an elective matter.

In conclusion, I am prompted to interject a comment regarding the possible fate of such curricula as the one just described. It is our opinion that the time has come to re-open the question of accrediting engineering physics in engineering colleges. Many of you may recall that this question was discussed at the summer meeting of this Society several years ago. At that time it was concluded that physics was not advanced to the point where recognition could be granted by such a group as the E.C.P.D. But I wonder if the situation is not different now. The curriculum just described seems to appeal to industry on a par with electrical, mechanical, civil and chemical engineering. The last report of the E.C.P.D. included "general engineering" on the approved list for many institutions. Certainly engineering physics, as it is interpreted and developed at the University of Maine, deserves as much consideration. In fact, it has many of the characteristics of general engineering, while at the same time it carries the student farther into the science behind engineering, and, for a selected group, has its definite place in the offerings of the engineering college. Furthermore, it would seem that the position of physics in the present war is such as to make the immediate future the logical time to reconsider the question of placing engineering physics right on a par with the other recognized branches of engineering.

Whither Engineering Education*

By ARTHUR V. SHERIDAN

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In approaching a discussion which permits differences of opinion, candor and discretion combine to suggest the wisdom of prefacing any discourse with a statement to the effect that what is set forth is intended as an expression of personal belief or conviction submitted purely as one man's opinion. Such is the following presentation which contemplates the role of education and the responsibility of the engineering educator in preparing the Engineer of tomorrow for public service. In order to develop this theme some thoughts, relevant to education in general as fundamental to the scholastic training of engineers, are in the speaker's opinion warranted.

Nineteen centuries ago, according to tradition and sacred history, there occurred near Rome an incident which has come down through the years to be beautifully recounted and enshrined in the annals of literature by Sienkewiecz, the Polish author. A challenge, in the form of an inquiry, has served to immortalize the incident, "Quo Vadis"—"Whither Goest Thou." One could, today, in all propriety, issue a similar challenge concerning human society. Quo vadit illa—whither is it tending and what is its goal? Are its multitudinous endeavors conducive to a higher civilization or does the very multiplicity of its elements presage chaos? Can man force a decision or is the denouement beyond his ken and power?

It is perhaps redundant to suggest that Society today is a highly mechanized, interrelated gregarious collection of human beings. That it is the best possible form of existence no one contends.

Man's progress in knowledge of the physical universe and in the resultant material developments has not been accompanied by pronounced moral or ethical advances. Unfortunately neither the realm of spiritual understanding nor the capacity to inherit wisdom has been appreciably expanded since the advent of the Christian era. Let him who questions this reflect that concerning the whence and why of man's existence, the when and where of his departure, the essence and nature of his soul, the philosophy of life, or the regulation and control of his passions—he is no farther advanced nor better informed than were the great thinkers of 2,000 years ago. The intangibles of life are as elusive as ever. Men still preach and promise millenniums unmindful as ever of their inability to unify subjective and objective nature. Perhaps the greatest need of mankind is the light to appreciate that while civilization has

* Presented at a meeting of the Middle Atlantic Section, S. P. E. E., Manhattan College, December 4, 1943.

changed human nature has not—at least not to an appreciable degree.

Submitting that the civilization of the moment springs primarily from the application of science to the aspirations of men, the engineer as the instrumentality of such civilization looms as the least dispensable servant of the present material society. Acceptance of this role implies responsibility and qualification adequate to improve and ameliorate those conditions which give rise to human misery.

The process of preparation for a role is primarily that termed education. The results of such preparation depend largely upon the validity of the process. What of the aims, accomplishments and techniques of education as generally manifest? To what extent has education fulfilled its role as pedagogue leading the children of successive generations to the school, or arena, of life? Is there justification for the contentions of its militant proponents who, like unto the advocates of every social order, make of it the panacea for all the ills that beset society. Not even religion promises with so much assurance. Is it not true that formal or scholastic education must accept at least a measure of responsibility for current offenses against peace, justice and morality? How otherwise can it justify its claim for recognition on the credit side of the ledger of human society?

The subject of post war education is presently running the gamut of public and private discussion and debate. In every proposal concerning the kind of community, nation and world that will, or should, prevail after the close of hostilities, there is included the item of education as a sine qua non of the social justice and economic equality promised for tomorrow, generally with but little regard for the lessons of history.

After traveling several thousand years with education constantly advancing and the scope and horror of war continually expanding, society might well inquire, without being too facetious, what is the relationship, if any, between strife and education? In the light of experience, can it be justly contended:

1. That war is inevitable and that education has no influence upon it;
2. That education begets war;
3. That education can prevent or alleviate war.

If one accepts either of the first two opinions, the third is automatically excluded. If on the other hand, one postulates the last belief, then that which parades as education is misnamed. Without benefit of this somewhat specious reasoning one can none the less contend that—if we wish to hold to the belief that education can be a factor incident to the promotion of tranquility and forebearance, a review of its present forms and methods should be undertaken ere embarking on the mission of assuring peace and plenty to a troubled world.

An appraisal of education is not alone a desideratum but a challenge to society in general and to the educator in particular. What is education? What are its functions? What are its limitations? Is it a panacea for the ills, social and economic, that plague the body politic; shall it accept empiricism as the sole basis of truth or shall it recognize the a-priori principles and methods of transcendentalism; should it stress the use of deductive or inductive processes or should it combine them in its pursuit of knowledge; should it bar revelation from the realm of its juris-

diction; is pragmatism a justifiable basis for individual or mass conduct; can it accept, for example, that philosophy, as etymologically defined, is love of wisdom, or must it follow the example of Herbert Spencer and expend two thousand words in the form of a dissertation that confuses rather than defines philosophy? Do studies in the so-called humanities develop true culture more readily than similar efforts in the field of science? Has not the term science been so prostituted as to practically nullify its significance in the realm of knowledge? Can education expect to comprehend and explain human nature in the manner and to the extent that it does physical nature? Should not education aim first to make men good rather than fit? These are but a few of the fundamental propositions that call for the reflection and decision of him who, seeking to demonstrate the effectiveness of education, should first establish the same upon a more enduring basis before attempting further expansion. Perhaps the answers in many, if not most, instances will prove to be no more conclusive than, if as wise as, the statement of St. Augustin—"Who knew, in his own mind, what time was; but knew not when asked to define or explain." In any event, the responsibility that accompanies education as a process justifies a thorough review of its present precepts and forms regardless of the conclusions that might be forthcoming.

In the light of the opinions offered and the questions posed, the speaker would submit several concrete suggestions with which to justify his Socratic attitude toward education as a process. These include

1. Education is a means toward, and neither the end nor the essence of, human enlightenment; nor should the form be substituted or mistaken for the substance of education.

2. More and more scholastic training is not per se the remedy for unsatisfactory social conditions. If the medicine previously administered has proved unequal to the occasion, it is a change of prescription, rather than increased dosages of the ineffective potion that should be considered. A re-orientation of formal education, with emphasis on making man good as well as fit is a sine qua non of an enduring society. Order, peace, justice and stability cannot prevail without the general acceptance of unchanging moral values, high ethical standards and the correct application of knowledge.

3. Peace and contentment are not inherent in knowledge or its handmaid education. Let us suppose for a moment that all mankind were possessed of baccalureate degrees. Would society be one whit nearer to an optimum of peace on earth or the elimination of mental pain and sorrow? Would the universal possession of doctorates eliminate differences of opinion? Do professors manifest love, hate, ambition and intolerance to a lesser degree than laborers? Would a state of deans and prexies be a happier one than that of farmers and merchants or even of Kaffirs and Eskimos? Is there not greater evidence of true philosophy in the social and moral practices of the ancient Chinese and Hindus than is found in most Occidental learning? Indeed, is there not depth in the poetry of the self-trained but great scholar who so aptly said in verse:

Lo! The poor Indian—whose untutored mind
Sees God in clouds or hears him in the wind;

His soul proud science never taught to stray
Far as the solar walk or milky way;
Yet simple nature to his hope has given,
Behind the cloud-topped hill an humbler heaven.

4. The true purpose of education is not the achievement of man's independence but, rather a fuller appreciation, of his dependence upon the source from which emanates the universal laws and proscriptions which circumscribe his attainments and restrict his independence to moral controls and the common welfare of the society of which he is a member.

5. The promiscuous use of the term science has well nigh destroyed its connotation. Since Herbert Spencer, and it is from such sources that the abuse of the term finds scholastic justification, defined science as simply a higher development of common knowledge, the propounders and professors of well nigh every ology and ism have sought, first respectability and then, approval for their theories by attempting to clothe them in the garb of immutability. This indiscriminate use of the term is, in the opinion of the speaker, one of the most baneful influences of the times. Immature minds do not distinguish between the validity of objective physical science and subjective theories. To them both are equally infallible once they are presented as science. The establishment of an Academy of Science, composed of eminent scientists, engineers, doctors and scholars, and cloaked with the authority to restrict the use and prevent the misuse and exploitation of the term, would be a real forward step in education and in the protection of society.

6. The term academic freedom has become a by word that oft times serves strange and questionable causes and frequently imputes unwarranted martyrdom to certain persons. No one questions the civil right to individual opinions and convictions and the right to express the same, except where actually dangerous to the rights of others. However the right to use the class room provided by public funds, especially where youth is concerned, for unrestrained dissemination of personal doctrines and ideas contrary to public standards of truth and morality and provocative of crime or disloyalty, is no more justified than the right of a doctor to engage in abortive or criminal practice. If academic freedom is to be circumscribed only by personal opinion, why not extend complete professional freedom to doctors, engineers, chemists and others by permitting them unrestrained use of individual judgment in matters of human life and property entrusted to their care? Abuse of right and privilege, whether in education, medicine, engineering or any other calling, is unwarranted and the limitations of academic freedom should be recognized as inseparable from its existence.

So much for the process called education. Whether justly or otherwise, a substantial part of mankind believes that it can develop a new society from which will flow the blessings of social justice. Such is indeed a consummation devoutly to be wished. In any event the concepts and methods incident to its practice are the concern of all men and merit their attention. Educators, including those in specialized and professional fields, have an additional responsibility. This is particularly true in the case of the engineering educator, for upon him devolves a dual role. He must teach men the subject matter of engineering. He must also teach

them how to use and not misuse science. Preservation and promotion, not the destruction, of human society must be the motive behind the practice of the professional engineer.

Again one is prompted to inquire, this time, concerning engineering education. Leaving its relation to engineering practice for later consideration one may opportunely ask: What of its processes and trends generally? What subject matter should it comprehend and how shall the same be ascertained? To what extent can scholastic training furnish the necessary preparation and how must this be supplemented by individual character, aptitude, endeavor and experience? How well is engineering education today fulfilling its role of mentor to the engineer of tomorrow?

Much has been written and more spoken on these topics during recent years. Various schools of thought have given voice to their views. Hence it is probable that more engineering educators have definite and justifiable opinions concerning engineering training than they have on the more general subject of education itself. Yet as teachers, it is obvious that they, too, apply the techniques and methodology of basic education. For example, during the past century form has become almost a fetish in the development of institutional instruction and engineering schools as a whole conform to practices that frequently tend to make of the individual an omnium-gatherum rather than a thinker. Fortunately the very nature of scientific application calls for demonstration, hence the training received by the engineer compels the reflection incident to proof. Thus while engineering training may have escaped some of the defects inherent in present educational form, it is perhaps due to accident rather than design that it does so.

In keeping with general practice, the tendency in engineering education has been toward division and specialization. This, together with the formation of societies restricted to specialized practitioners, has confused the public and given rise to the common opinion that engineering is a heterogeneous combination of callings rather than a single profession with specialties comparable to those of law and medicine. Furthermore, this process has encouraged and justified the indiscriminate use of the term engineer through the application of dozens of descriptive qualifying words such as custodian, exterminating, human, etc. The practicing engineer and the public, often in the face of actual opposition from certain technical societies and engineering schools, have finally, through the medium of professional practice acts and professional societies, halted this trend and their efforts are well on the way toward establishing the unity of the profession. Engineering schools should collaborate in establishing basic unity for the calling of engineering.

There are some wide differences of opinion concerning the subject matter that should be included in engineering curricula. There are also differences concerning the manner in which the same should be taught. Should engineering courses be uniform? Should they place greater emphasis on the humanities and if so should this be accomplished by expanding courses or curtailing technical subject matter? Should such studies be pursued prior to, coincidently with, or subsequent to, engineering subject matter? The

answers to such questions can only be ascertained from experience and such experience must come from public and professional sources. Here again, these sources have provided the means for ascertaining the range and amount of education that should be provided. The method should remain the province of the school. In the future the Registration Boards in the several states will determine whether or not the candidate for admission to the practice of engineering possesses the essential character and knowledge to justify entrusting him with the prerogatives of a professional man. It remains for the practicing engineer, through public agencies, to determine and maintain the required standards. It remains for engineering schools to establish such curricula as will adequately prepare the student to meet public standards. Those who fail to provide the essential education will soon fall by the wayside.

Can schools complete the education of an engineer? One is safe in answering negatively. At best, they afford the shortest and safest road toward the objective of professional practice. They are a means and not the end and no amount of scholastic preparation can supply the character, judgment and experience indispensable to the assumption of major responsibility for life, health and property affected by practice. However, scholastic training can furnish the general basic knowledge, develop the incentive to apply the tools of nature, indicate the accepted processes of thought and inspire the spiritual influences for moral action, all distinguishing features of sound education of whatever sort.

Accepting accomplishment as evidence, and surely there is no better measure, engineering education has to date fulfilled its specific role to an extent unexcelled by any other scholastic endeavor. That role has been the training of engineers as scientific and technical experts. Until recently little thought has been given to preparing the engineer for administrative and political roles. With the increasing dependency of society upon the provisions of applied science the responsibility of the engineer can no longer be restricted to the building of material civilization. He must help to administer the society for which he is so largely responsible. He must do so:—to progress the march of mankind by providing an understanding leadership; to prevent the misuse and exploitation of his contributions to society; and last, but perhaps not least, to protect himself against intolerant ignorance that would condemn him for his contributions to human welfare and relegate him to a subordinate role in the affairs of government and industry. How may his proper role be assured? The answer is undoubtedly to be found in the possession of that additional training, knowledge and technique that will enable him to compete for leadership on equal terms with those engaged in other fields than engineering. It is for this purpose that practicing engineers are so insistent that more adequate training in the so called humanities be required of engineers for admission to professional status and not because of a belief that there are any inherent, superior moral or ethical attributes attached to the study of the said humanities as compared with the sciences. The ethical standards of the engineer are today more rigorously adhered to than those of legal and medical

practitioners. But without the tools and skill to apply them to the conduct of social units, they remain but suppressed desires, to use a rather discredited but easily appreciated philosophy of action.

Today the practice of engineering is carried on primarily under two sponsorships: viz., public service and private industry. As time marches on the engineers in these services will find their efforts directed more and more toward similar, if not identical, ends. The scope of governmental activity and influence is constantly expanding. The regulation of industry by government is continually increasing. As a consequence, the objectives may one day be common. The practices and methods of achieving ends will become more and more alike. Eventually, if such trends continue, the two should merge and to all intents and purposes the socialized state will have arrived, though not by the method predicted by Karl Marx. While reason might lead to this conclusion, the speaker trusts that the idiosyncrasies of the individual will prove sufficient to prevent the completely socialized state, whether by evolution or revolution. Regardless of the ultimate, or, perhaps more accurately, the penultimate, antepenultimate or even a dozen anterior states, the practice of the engineer is going to deal more and more with matters social; and under the general category of social must be included legal, political and economic considerations.

So far as the engineer in public service is concerned, he functions through governmental agencies. His practice in all instances demands, in addition to engineering knowledge, a thorough understanding of administrative law, as well as familiarity with political, social and economic influences. Without such the engineer in public service cannot assume any degree of responsibility, effect any vital work or give decent expression to his imagination. To this extent must the engineer, who contemplates a career in public service, add to his general training. To a lesser extent, the same is true of the engineer in certain private industries, especially those often referred to as public utilities. Because of the fact that the services commonly provided—and all too often taken for granted—for urban existence are in general furnished by municipalities and quasi-public corporations, the practice of what might be termed Municipal Engineering has become a definite and increasingly large and important field that serves to illustrate the career of the engineer in public service generally. The plan, design, construction, operation and maintenance of a city are basically physical considerations which call for engineering of every type. The proper coördination and interrelation of the physical with the social and economic threads of the municipal cloth require application of the knowledge and techniques unique to the practices of the lawyer, doctor, sociologist, economist, real estate expert, business man and others, as well as those of the engineer.

It is perhaps pertinent to touch here on a trend which stresses the need for emphasis on Municipal Engineering. The present war has demonstrated that physical rather than political units should be regarded as entities for defense purposes. This is equally true of peace time administration. The adequate planning of municipalities will in the future probably

be on a regional basis. The controls will be the physical limitations of the area rather than arbitrary political lines. Water supply and drainage sheds, sanitation, power, communications, transportation, traffic and other factors of a physical nature will in general determine future political boundaries. This will necessitate a definite and controlling engineering influence in the administration of government.

In addition to professional and civic arguments, there is an economic justification for presenting to students of engineering the scope and the opportunities of Municipal practice as an alternative career to structural, hydraulic, mechanical, electrical or chemical engineering. It is the speaker's opinion that the need for the techniques of engineering planning will shortly be so great as to provide an unusually large field for the engineer who prepares himself for municipal work. European cities will have to be rebuilt and, from present indications, comprehensive planning is already under consideration. Several generations will be required to rebuild England alone. New techniques applied to housing, traffic problems and other prevailing unsatisfactory conditions, including unstable and insupportable land values, will likewise make imperative countless undertakings throughout this country.

The engineer who contemplates a career in public service, would do well to remember that nearly every branch of engineering is involved and that his practice may cover one or several specializations. His horizon of knowledge, though less intensified than that of other specialists, must be extended to include the basic planning, designing, execution and operation for public utilities and private enterprise as well as for governmental agencies. All these activities must be planned and regulated so as to envision a balanced production, distribution, employment and economy for the municipality as a whole. This is of course an objective little likely of more than partial realization. The task of the Municipal Engineer is to coördinate as well as initiate plans and proposals for public and private endeavor. Only the person possessed of a working knowledge of the subjects involved can intelligently attack the problem of interweaving the factors of Municipal Existence. Such also is the case for the engineer in public service generally, and, to some extent for him in industry.

This leads once more to the question of engineering training and the special form or forms that it must take in the light of its relation to practice. As previously suggested there is practically a unanimity of opinion among practising engineers that more adequate training in social, philosophic, literary, æsthetic, economic and legal subjects should be required for admission to professional status. There is also recognition of the fact that there are many essential technical services incident to engineering practice, which, while calling for the application of certain engineering principles and techniques, do not require the additional training essential to those who seek professional recognition. On the other hand there is a growing field of specialized practice which calls for research and experience supplemental to that recognized as minimum for entrance to the profession. How best to effect, within the framework of formal education, a plan comprehensive enough to meet

these several requirements is a problem that challenges engineers, engineering educators and others interested in the future of the profession.

Many engineers believe further that a codification of engineering classifications is needed and that a syllabus containing fewer and more logical subdivisions of what is fundamentally one profession should be developed for scholastic purposes. The term Civil Engineer originally covered all the existent branches of the profession and was used to distinguish between civil and military pursuits. A step toward the accomplishment of the ends referred to might be found in the following educational program: A basic course—consisting of a thorough training in mathematics, the pure and applied sciences, fundamentals of engineering theory applicable to all branches of engineering and selected studies in the humanities—leading to the degree of Bachelor of Engineering. This would enable the graduate of such basic course to seek immediate employment in technical and other fields of activity where educational, but not professional, backgrounds are essential. For those seeking professional status, additional scholastic study covering the specific application of science and engineering principles to various forms and types of engineering, together with further investigation of the humanities, including special reference to administrative law and to codes of ethics and practice involved in the work of a professional practitioner, or the equivalent experience and knowledge, might be a minimum requirement for the designation of Civil or Professional Engineer to be acquired through state examination and registration. This would approximate an internship or apprenticeship of perhaps two years. Further professional post graduate study or experience in selected engineering work could then be required for specialist designations such as mechanical, electrical, structural, hydraulic, chemical, mining, military and municipal engineers with perhaps a doctorate as academic or institutional award equivalent to a Doctor of Public Health or of Internal Medicine.

You will note that form has been minimized in this proposal. Time, credits and other present scholastic methods of measuring education should be subordinated to accomplishment. Ability, talent and determination are not equal in all men. Recent army investigations have in many cases been most convincing in this respect. It is the end for which education purports to train, not the processes of education that should be the criterion of knowledge or attainment.

To conclude one might summarize by suggesting that while education is not and can never be a cure for all the social ills born of the emotions and imperfections of human beings, it can, by reorientation and emphasis upon morality, make man more conscious of his dependent state in this world and aid materially in alleviating human misery.

The progress of civilization has been confined almost exclusively to material advances. Such advances have not been accompanied by, nor provocative of, spiritual progress. As the principal cause of modern civilization, the engineer has a heavy obligation to society. His participation in its affairs is indispensable to its maintenance and his leadership to its future progress. All professions,

especially engineering, are approaching what might be referred to as a socialized pattern. Ability to function within such framework calls for planned education.

Engineering education, to date, has done an excellent job, but within a scope too narrow for the role the engineer of tomorrow will be called upon to assume. Failure to measure up to this role will reduce engineering to the status of a skilled craftsmanship, subordinated to the policies and dictates of others better equipped for administrative authority and leadership in a society composed of fallible human beings. To meet the impending exigencies, engineering education should be revamped in such manner as to train men progressively for (*a*) technical performance; (*b*) administrative, as well as engineering, responsibility; (*c*) special scientific and research accomplishment directed toward constant advances in the several fields of engineering, as well as qualification for the role of technical and professional man. This does not for a moment *preclude* the development or manifestation of talent or ability by other means, nor does it *insure* the objectives noted in individual instances. It does purport a definite means toward an objective.

Throughout the educational process of training, there should be stressed the fact that engineers are human beings whose life work is among and concerned with other human beings. Spiritual concepts and values must ever be present to prevent the misuse and exploitation of science. To make man conscious of the fact that there are limitations to his role as administrator of earthly dominion should be no less the aim of education than to exhort him to material progress. Engineering must be the agent of human welfare and its application must not be destructive of human ends. Finally let us engineers and as humans remember that:

> We are but forders in the stream of time
> Spending whole decades vainly feeling for
> A sober stone ere we put forth the foot
> Each clicking of the clock announces change
> But only centuries record advance.

At all times and in all climes it has ever been patent that man proposes but God disposes and humanity, particularly the scientist and engineer, can best justify its existence by honest endeavor, tempered with humility, born of the realization that man is cognizant of but a smattering of the laws and purposes ordained by the Great Engineer from whom emanated creation and who holds in the hollow of His hand the destiny of the universe.

The Yale Scholastic Aptitude Tests as Predictors of Success in the College of Engineering

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Introduction

The prediction of success in the college of engineering is an important problem in the selection and guidance of students who study for careers as professional engineers. While the successful completion of formal training prerequisite to professional licensing is no guarantee of ultimate success in any profession, it is, nevertheless, a necessary step in the education of those now admitted to practice in most professional fields. Definitive studies of student abilities, capacities, and previous achievements as related to success in the engineering curriculum can provide important implications for selecting and guiding those who propose to begin engineering study.

For a number of years, the E.C.P.D. and S.P.E.E. Committees on Student Selection and Guidance have conducted studies of various types of educational measurement most appropriate for counseling beginning engineering students. During the academic years 1941–42 and 1942–43, these committees sponsored a joint project under the direction of R. L. Sackett and Allan R. Cullimore, committee chairmen. Previous discussions of the plans of these committees have been presented in this JOURNAL * and in the E.C.P.D. Annual Reports.† Under this sponsorship, Dr. Russell S. Bartlett of the Newark College of Engineering administered a selected battery of Yale Aptitude Tests in a group of coöperating colleges and universities. Before the study was completed, Dr. Bartlett accepted the position of Headmaster of the Gunnery School and, consequently, some of the initial plans for securing validation data were altered. The Yale tests having been given, however, the committee's immediate responsibility was to secure the available measures of freshman achievement and to determine to what extent the Yale tests were of value in predicting success in the engineering curriculum. Validation data were secured from the coöperating colleges and assembled by the committee. These data were then presented to the writer for analysis and interpretation.

The purpose of this article is to report the findings of the Committee's study of the effectiveness of the Yale Aptitude Tests for predicting success in the engineering curriculum. It was

* Russell S. Bartlett, "Guidance and Placement of Engineering Students," Vol. 33, No. 7, March 1943, pp. 535–51.

† E.C.P.D., Tenth Annual Report, pp. 20–22. Eleventh Annual Report, pp. 6–9.

prepared for the S.P.E.E. and E.C.P.D. Committees on Student Selection and Guidance at the request of the two Chairmen, R. L. Sackett and Allan R. Cullimore.

The Collection of Data

Six colleges of engineering coöperated in the project and administered all or part of the Yale Aptitude Battery.* In three of these colleges, the entire battery of six tests was administered to all entering students; two colleges administered five tests; and the sixth college administered only four tests. For purposes of this report, the six colleges were randomly assigned identification letters and are designated as Institutions A through F.

The Yale tests were administered to freshman engineering students at the six coöperating institutions near the beginning of the fall semester, 1941. Approximately 1,800 students were tested in accordance with the procedures established by Dr. Bartlett and the Committee. The test and progress records for these students were assembled and carefully checked. Students with incomplete test records and students who withdrew during the freshman year for reasons other than scholastic failure were eliminated from the study. Complete test records and verified course marks together with general reasons for scholastic failure were available for 979 students.

The Committee originally planned to administer a series of objective achievement examinations at the end of the freshman and sophomore years, the results of which were to be taken with grade-point averages and instructor rankings for purposes of establishing reliable indices of student achievement. Of these criteria of achievement, the only one available for research purposes was the marks in individual courses. The Committee recognized, of course, that the study could not be as satisfactory as initially planned, but because of the resignation of Dr. Bartlett who was in charge of the administration of the project it was impossible to carry forward the original plans for collecting more reliable validation data.

Description of the Yale Aptitude Tests

When the Committee instituted the present study, it examined a number of objective tests which seemed to offer possibilities for selecting and guiding beginning engineering students. The Yale Aptitude Test battery was chosen for study. With the advice of Albert Beecher Crawford of the Department Personnel Study of Yale University (compiler of the tests), six tests of the battery were selected as likely to afford good discrimination between aptitudes for several areas of study. Dr. Crawford agreed to make available for the use of the Committee such tests as were necessary for its purposes.

The Yale tests employed by the Committee are briefly described in the following paragraphs.*

* The institutions coöperating in the project were Newark College of Engineering, Northwestern University, and the Universities of Texas, Tennessee, Florida, and Missouri. Pasadena Junior College, Pasadena, California, coöperated during the early stages of the project, but did not assemble validation data.

* The identification on numbers assigned the tests used in this study do not correspond with the notation employed in the Yale Aptitude Battery. The original notation is as follows:

I. Verbal Comprehension
II. Artificial Language
III. Verbal Reasoning (not used)

Test I—Verbal Comprehension

This test is a general verbal test consisting of three sub-tests; paragraph comprehension, word relations, and synonyms. The paragraph comprehension section consists of a series of paragraphs in which one word destroys the meaning of the paragraph. The student is required to select this word. There is no provision in this subtest for measuring the students' comprehension of the central thought of the paragraph other than the recognition of a word which is inconsistent with the central thought. In the word-relations section, the student is required to recognize antonyms and parts of speech applying to words whose parts of speech are given. Part III is a test of the student's ability to recognize synonyms of given words.

Test II—Artificial Language

In this type of aptitude test, the student is supplied with a set of language rules and an artificial language vocabulary. In Parts I and II of this test, the student is required to translate English words and sentences into the artificial language and to translate words and sentences in artificial language into English. In these parts of the test, the student is permitted to refer to the given rules and vocabulary, but in Part III he must rely on his *memory* of the rules and vocabulary presented in Parts I and II. In this sense, then, Part III is a very good test of the student's ability to remember and apply what he has recently studied.

Test III—Quantitative Reasoning

This is a special type of quantitative reasoning test. In Part I the student is presented with a series of paragraphs containing sets of data illustrating mathematical principles. The student is required to discover and apply the principle underlying each set of data. Part II is correctly described as a number series test. The student is presented with various number series and is required to select from a given set of numbers the one which applies to each series.

Test IV—Spatial Visualizing

In Part I of this test, the student is presented with various sets of cubes and is required to count the cubes which fulfill certain specifications. In Part II of this test, the student is presented with drawings of two orthographic views of an object and is required to select from four suggested views the one which applies to the given set of two. In the third part of this test, a number of irregularly shaped figures are presented and the student is required to recognize combinations of various patterns.

Test V—Mathematical Aptitude

This test is a highly specialized mathematics test. Part I is correctly described as a test of ability to manipulate algebraic expressions. In each case the student is presented with an algebraic expression, or series of expressions, and is required to solve for one unknown quantity. Part II is confined to algebraic

IV. Quantitative Reasoning
V. Mathematical Aptitude
VI. Spatial Visualizing
VII. Mechanical Ingenuity

formulation. In this section of the test, the student is required to translate a verbal statement into an algebraic equation.

Test VI—Mechanical Ingenuity

This test is probably better described as a mechanical comprehension test. Drawings of mechanical devices are presented and the student is required to recognize and apply the principles involved. The student is also required to solve a number of elementary problems in kinematics. Performance on this test may be indicative of mechanical ingenuity (or lack of it) but the character of the questions presented is quite similar to that employed in so-called tests of mechanical comprehension.

PERFORMANCE ON THE TESTS

Performance on the Yale Tests is reported in terms of a system of scaled scores in which the mean is 50 and the standard deviation is 10. This scale, originally adjusted to the ability of entering college freshmen, applies equally well to engineering students in this instance. The mean scores for the combined groups presented in Table I closely approximate the mean of the scale-score system; likewise, the standard deviations of the scores represented by these means do not differ markedly from the intended standard deviation. This can be interpreted to mean that, with respect to difficulty, the Yale Tests are appropriately adjusted to the aptitudes of beginning engineering students as judged by the performance of students enrolled in the institutions participating in this study.

The intercorrelations of performance on the six Yale Aptitude Tests employed in this study are shown in Table II. The correlations between performance on *Test I—Verbal Comprehension* and the remaining five tests in the battery range from .182 in the case of *Test IV—Spatial Visualizing* to .382 in the case of *Test III—Quan-*

TABLE I

MEANS AND STANDARD DEVIATIONS OF SCORES ON YALE APTITUDE TESTS

Institution	N	Tests											
		I Verbal Comprehension		II Artificial Language		III Quantitative Reasoning		IV Spatial Visualizing		V Mathematical Aptitude		VI Mechanical Ingenuity	
		M	σ	M	σ	M	σ	M	σ	M	σ	M	σ
A	60	52.17	11.87	47.52	8.92	52.42	9.25	55.05	10.40	54.50	10.81	57.15	8.51
B	60	43.80	9.48	50.42	11.09	52.55	9.92	52.60	12.54	54.43	12.30	51.35	10.68
C	202	50.83	9.31	55.40	9.97	60.31	9.09	59.32	9.59	60.47	9.74	57.71	9.79
D	201	*	*	49.04	9.15	52.82	10.11	50.38	9.75	52.78	9.15	50.55	8.20
E	323	*	*	47.37	9.99	49.84	10.95	50.40	10.64	54.01	11.08	53.19	9.23
F	133	*	*	*	*	47.74	10.42	44.30	9.47	50.50	11.16	53.05	8.53
Combined for A through F		49.77	10.21	49.85	10.45	52.60	11.15	51.77	11.31	54.61	11.12	53.64	9.61

* Not given.

TABLE II

INTERCORRELATIONS AMONG SIX YALE APTITUDE TESTS *

Tests	Tests					
	I	II	III	IV	V	VI
	Verbal Comp.	Art. Lang.	Quant. Reas.	Spatial Visual.	Math. Apt.	Mech. Ing.
I. Verbal Comprehension						
II. Artificial Language	.349					
III. Quantitative Reasoning	.382	.552				
IV. Spatial Visualizing	.182	.444	.568			
V. Mathematical Aptitude	.275	.480	.686	.569		
VI. Mechanical Ingenuity	.357	.320	.536	.570	.565	
Grand Mean	50.0	50.3	52.4	52.0	53.5	52.3
σ	10.2	10.2	10.9	10.9	11.2	10.0

* $N = 1{,}046$ except for those correlations involving Verbal Comprehension where $N = 427$. These intercorrelations include the test scores for 67 students whose academic records could not be verified.

titative Reasoning. The intercorrelations among the remaining five tests, however, generally exceed .45. The lowest correlation of performance on any pair of tests (.182) was that between *Test I—Verbal Comprehension* and *Test IV—Spatial Visualization*. The highest correlation of performance on any pair of tests (.682) was that for *Test III—Quantitative Reasoning* and *Test V—Mathematical Aptitude*.

It is interesting to note that, in this case, performance on *Test II—Artificial Language* is more highly related to performance on the tests of mathematical and spatial visualizing ability than it is to performance on the verbal comprehension test. It does not follow, however, that student abilities are necessarily related in this manner. In interpreting correlations of performance on two tests, it is necessary to maintain an operational point of view, defining the results in terms of the tests and types of students involved. This is especially important since the interrelationships among a second set of tests purporting to measure the same abilities may differ markedly from those reported here. In some cases, these differences can be attributed to the technical construction and samplings of the particular tests employed, rather than changes in fundamental relationships among the abilities purportedly measured by the tests.

GENERAL DISCUSSION OF THE RESULTS

In this study, the Committee was primarily interested in the general effectiveness of the Yale Aptitude Battery for predicting scholastic success during the first year of the engineering

curriculum. The Committee was not concerned at this time with the prediction of success in individual courses within this curriculum. The freshman curricula of the coöperating institutions were not uniform, however, and it seemed desirable to group various courses for purposes of study. Three classifications of courses were adopted: (1) *cultural subjects*—English, history, social science, and other socio-humanistic courses; (2) *scientific subjects*—mathematics, physics, chemistry, and other subjects which are perhaps properly termed preëngineering subjects; and (3) *engineering subjects*—engineering drawing, descriptive geometry, engineering problems, and similar pre-professional subjects.

With the grade-point averages in the special subject areas and the freshman average as criteria, the correlations of test performance and student success in the engineering curriculum were calculated for a combined student population. The results are presented in Table III. It should be pointed out here, in all fairness to the tests, that this type of analysis lacks precision.* In the first place, the variations in college standards of selection are such that the true correlation tends to be lowered by grouping in this manner. In the second place, achievement as well as student ability varies from institution to institution. On the other hand, the increased range of scores resulting from grouping tends to increase the magnitude of correlations between the performance on the tests and indices of student success. Judg-

* Such indices of success are not strictly comparable from college to college. The grade of A in one college may not be comparable with the same grade in a second college. Had it been possible to administer a uniform battery of achievement tests to all students, the results would have become strictly comparable. Such results, however, would also be an imperfect criterion of student success at the various colleges.

TABLE III

CORRELATIONS OF YALE APTITUDE TESTS WITH ACHIEVEMENT IN FRESHMAN COURSES *

Tests	Cultural Subjects		Scientific Subjects		Engineering Subjects		Freshman Average	
	N	r	N	r	N	r	N	r
I. Verbal Comprehension †	105	.398	120	.299	116	.059	120	.310
II. Artificial Language	595	.356	641	.353	610	.238	643	.363
III. Quantitative Reasoning	595	.434	641	.483	610	.353	643	.504
IV. Spatial Visualizing	595	.236	641	.364	610	.411	643	.385
V. Mathematical Aptitude	595	.373	641	.509	610	.387	643	.513
VI. Mechanical Ingenuity	595	.189	641	.312	610	.269	643	.307

* The correlations presented in this table were calculated from combined data for four institutions. Institution F was omitted from this analysis since only four of the six tests were administered at that institution. Institution C was not included because of unusual selection and elimination policies which tended to reduce markedly the validities of the tests.

† Given at three institutions only.

ing from the subsequent analyses of results for individual institutions, it appears that the correlations reported in Table III may be fairly good estimates of the test validities.

While course grades and grade-point averages are not the most satisfactory or reliable criteria of student success, they do represent a crude measure of the student's progress in the engineering curriculum. Course grades, being unreliable in themselves, are difficult to predict with any great precision. It is important, therefore, in considering the test validities reported in this article to recognize the fallibility of the criteria employed. There is no reason to assume, however, that any one of the special criteria of progress, *e.g.*, grade-point average in cultural subjects, is more or less reliable than any of the others. It follows from this that the inadequacy of the criteria in no way affects an evaluation of the *relative* effectiveness of the tests of different aptitudes.

Success in such subjects as English composition, history, social science, economics, and speech involves a certain degree of verbal ability. It is to be expected, therefore, that tests which are highly verbal in character would prove of considerable value for predicting success in such subjects. In general, the results presented in Table III bear out this supposition. Performance on the tests of quantitative reasoning, artificial language, and verbal comprehension is most highly related to success in the cultural subjects in the engineering curriculum. The quantitative reasoning test is heavily weighted with the verbal factor, due in this case to the nature of the test exercises. Although this test requires the student to recognize and apply mathematical principles, the context is "foreign" to the student.* In this sense, *Test III—Quantitative Reasoning* resembles *Test II—Artificial Language*. The intercorrelation between performance on these two tests, in this case, was .552, further evidence of the overlap of these two tests.

With respect to predicting success in the cultural aspect of the engineering curriculum, the two most valid tests were as follows:

	Validity Coefficient
Test III—Quantitative Reasoning	.43
Test I—Verbal Comprehension	.40

While the validity coefficients for the verbal comprehension test is not high, it does not tell all the story concerning this type of aptitude test. Such tests are generally much more useful in guidance than this validity indicates. Verbal tests generally have a *negative* value for predicting success, that is, students who do very well on verbal tests may or may not succeed in engineering, but students who do very poorly on such tests rarely succeed in any college curriculum, engineering or otherwise. It is generally advisable, therefore, to include a verbal test in a selection battery, even though the test does not in itself predict grade-point averages or other measures of achievement with high precision.

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* Consider the following sample items from this test.

A series of experiments in a Martian laboratory shows the following relations when Neeters (N) of a gas are observed under different conditions of Wholan (W), all other conditions being equal.

$$\frac{N}{W}$$

(Tabulation)

34. How many Neeters are there for one Wolan? ( )
35. What will be the value of Wolan when 16 Neeters are observed? ( )

Tests of verbal ability are generally more valuable for predicting success in the so-called cultural subjects than in mathematics and science. The validity coefficients presented in Table III confirm previous research in this respect.

In general, tests of mathematical achievement or aptitude have proved most valuable for predicting success in the first year of engineering education. This is to be expected when we consider that most of the first year of this curriculum is devoted to mathematics and science, generally chemistry or physics. With respect to predicting success in this aspect of the curriculum, the two most valid tests in the Yale battery were:

	Validity Coefficient
Test V—Mathematical Aptitude	.51
Test III—Quantitative Reasoning	.48

In the "engineering" phase of the curriculum in the participating colleges, engineering drawing, descriptive geometry, and engineering problems were the typical subjects. Since these subjects involve both mathematical ability and spatial visualizing ability, it was to be expected that tests designed to measure these abilities would prove most predictive of success in this area of study. The three most valid tests for predicting success in these subjects were:

	Validity Coefficient
Test IV—Spatial Visualizing	.41
Test V—Mathematical Aptitude	.39
Test III—Quantitative Reasoning	.35

Ranked according to their validity for predicting success in the freshman year as a whole, the Yale tests arranged themselves as follows:

	Validity Coefficient
Test V—Mathematical Aptitude	.51
Test III—Quantitative Reasoning	.50
Test IV—Spatial Visualizing	.39
Test II—Artificial Language	.36
Test VI—Mechanical Ingenuity	.31
Test I—Verbal Comprehension	.31

For all tests taken together, the coefficient of multiple correlation as calculated by the Doolittle method was .58 with a standard error of .03. According to the theory of probability, this validity coefficient will not normally be less than .50 or more than .66.* Individual tests or batteries whose validity coefficients are less than .50 have little guidance possibilities. On the other hand, validity coefficients of .70 or over are not ordinarily obtained when course marks are used as the criterion.

* By chance alone, the validity coefficient would fall outside this range in only 5 per cent of the cases.

TABLE IV

THREE-VARIABLE COEFFICIENTS OF MULTIPLE CORRELATION FOR ALL POSSIBLE COMBINATIONS OF TWO TESTS AS CORRELATED WITH FRESHMAN ACHIEVEMENT *

$R_{A.12}$—.413				
$R_{A.13}$—.520	$R_{A.23}$—.514			
$R_{A.14}$—.456	$R_{A.24}$—.441	$R_{A.34}$—.518		
$R_{A.15}$—.542	$R_{A.25}$—.530	$R_{A.35}$—.554	$R_{A.45}$—.525	
$R_{A.16}$—.374	$R_{A.26}$—.415	$R_{A.36}$—.506	$R_{A.46}$—.399	$R_{A.56}$—.513

* $R_{A.12}$ is the coefficient of multiple correlation for Tests I and II as correlated with freshman average. The other entries in this table are read in a similar manner.

The multiple regression equation as calculated for these data is as follows:

$$\text{Freshman Grade Point Average} = .142\ X_1 + .027\ X_2 + .183\ X_3 + .091\ X_4 + .266\ X_5 - .107\ X_6 - 12.471.$$

An inspection of Table IV will reveal that each of two pairs of tests yields approximately the same validity as that yielded by the whole battery. These pairs are the following:

Tests I and V
Tests III and V.

For all practical purposes, a battery composed of Tests I, III, IV, and V would yield a relatively high validity as compared with the entire battery. If only Tests III and V were used, the diagnostic and guidance possibilities of the battery would be greatly reduced.

Variations Among Institutions

There is good reason to assume that the variations in student selection, curricula, and standards of achievement in a sample of six colleges of engineering are such that they should be considered in a study of this type. Consequently, the foregoing analyses, with the exception of calculations of the coefficients of multiple correlation, were extended to the data for all institutions except Institution F. These analyses are presented in Tables V through VIII.

It is rather obvious from an inspection of these tables that there is considerable variation in the validity of the Yale Aptitude Tests for institutional purposes, yet these fluctuations are to be expected in light of the typical variations in policies of admission to colleges of engineering. Despite the wide variations in test validity from institution to institution, the same general patterns of validity are in evidence in the results for individual institutions.

TABLE V

Correlations of Yale Aptitude Tests with Freshman Achievement in Cultural Courses *

Institution	N	Tests					
		I	II	III	IV	V	VI
		Verbal Comp.	Art. Lang.	Quant. Reas.	Spatial Visual.	Math. Apt.	Mech. Ing.
A	60	.428	.375	.482	.191	.429	.155
B	60	.480	.372	.491	.260	.238	.166
C	197	.307	.127	.261	.120	.089	.129
D	201	†	.361	.455	.170	.315	.218
E	289	†	.345	.410	.266	.427	.190
Composite A, B, D, and E		.398	.356	.434	.236	.373	.189

* English and speech in all institutions. Institution B also offered a social science course.

† Not given.

TABLE VI

Correlations of Yale Aptitude Tests with Freshman Achievement in Scientific Courses *

Institution	N	Tests					
		I	II	III	IV	V	VI
		Verbal Comp.	Art. Lang.	Quant. Reas.	Spatial Visual.	Math. Apt.	Mech. Ing.
A	60	.446	.405	.564	.227	.547	.305
B	60	.230	.415	.562	.450	.464	.393
C	202	.191	.214	.363	.232	.295	.232
D	201	†	.336	.472	.273	.446	.227
E	320	†	.344	.474	.408	.545	.340
Composite A, B, D, and E		.299	.353	.483	.364	.509	.311

* Chemistry in all institutions except Institution B where physics was offered. In mathematics, trigonometry, analytical geometry, and calculus were the typical subjects.

† Not given.

TABLE VII

CORRELATIONS OF YALE APTITUDE TESTS WITH FRESHMAN ACHIEVEMENT IN ENGINEERING SUBJECTS *

Institution	N	Tests					
		I	II	III	IV	V	VI
		Verbal Comp.	Art. Lang.	Quant. Reas.	Spatial Visual.	Math. Apt.	Mech. Ing.
A	56	.208	.439	.273	.567	.571	.348
B	60	−.041	.150	.376	.182	.394	.175
C	196	.112	.012	.161	.347	.151	.186
D	201	†	.235	.399	.396	.449	.286
E	293	†	.223	.377	.446	.358	.301
Composite A, B, D, and E		.059	.238	.353	.411	.387	.269

* Engineering drawing and descriptive geometry for all institutions except Institution C which offered Introduction to Mechanical, Chemical, and Electrical Engineering as freshman subjects. Surveying for Institution A; Engineering Problems for Institutions B and D.

† Not given.

TABLE VIII

CORRELATIONS OF YALE APTITUDE TESTS WITH AVERAGE FRESHMAN ACHIEVEMENT

Institution	N	Tests					
		I	II	III	IV	V	VI
		Verbal Comp.	Art. Lang.	Quant. Reas.	Spatial Visual.	Math. Apt.	Mech. Ing.
A	60	.428	.462	.543	.335	.627	.312
B	60	.276	.429	.610	.424	.472	.361
C	202	.250	.186	.364	.292	.271	.247
D	201	*	.332	.486	.309	.465	.275
E	322	*	.348	.486	.418	.536	.334
Composite A, B, D, and E		.310	.363	.504	.385	.513	.307

* Not given.

There are a number of possible explanations of the variations in validity of the tests among the coöperating institutions. Although the results of the Yale Aptitude Tests were not used for selection purposes during the conduct of the study, each institution employed certain admission criteria, most of which tended, in all probability, to reduce the heterogeneity of the group accepted by the institution. Furthermore, the variations in curricular offerings and requirements, standards of achievement, and policies of elimination contributed to these differences.

The effect of rigorous student selection on test validity is clearly demonstrated in this study. An inspection of Tables I and V through VIII indicates that Institution C has an unusual student population. In the first place, this institution employed rigorous selection techniques resulting in the selection of a large group of very able students. These students were particularly outstanding in those aspects which are especially important to the student engineer, *i.e.*, mathematical and spatial visualizing abilities. Furthermore, this particular institution was engaged in experimental work and at the time the study was terminated only 1 per cent of the students had failed. These factors contributed to the low test validities presented in Tables V through VIII. Since this institution was atypical in the extreme, it was not included in calculating the composite validities.

There is some evidence, in certain instances, that it is not justifiable to combine the results for several institutions, since this tends to lower the estimated validities of the individual tests. This is particularly true where standards of student selection and achievement differ markedly. If estimates of validity are to be dependable, however, they must be based on a sufficiently large sample. Correlations based on a sample of 60 students, as in the case of Institutions A and B, are not sufficiently reliable to inspire

much confidence. On the other hand, the validities reported for Institutions D and E are much more dependable as far as those particular institutions are concerned.

The lack of uniformity in test validities among the participating institutions suggests that factors within an institution determine to a large extent the effectiveness of tests employed for selection and guidance purposes. These factors should be the object of further study on an institutional basis as well as a coöperative basis. The S.P.E.E. and E.C.P.D. Committees on Student Selection and Guidance are at present conducting studies of other approaches to measurement. These studies should throw additional light upon the effectiveness of objective tests for selecting and guiding engineering students.

Conclusions

Any conclusion with respect to the validities of the Yale Aptitude Tests as reported in this study must take into account the fact that grade-point averages were used as criteria. Considered in this light, the data seem to warrant the following conclusions for this or similar populations of freshman engineering students:

1. With respect to difficulty, the Yale Aptitude Tests are appropriately adjusted to the ability and capacities of pre-engineering students. The scale-score system of reporting performance employed with these tests applies to beginning engineering students as well as freshman students in general.

2. The intercorrelations of performance on the Yale Aptitude Tests form patterns consistent with results for other tests which purportedly measure the same abilities and aptitudes. These patterns suggest that mathematical ability is more highly related to visualizing ability than to verbal ability, and that the relationship between verbal ability and visualizing ability is very low.

3. The tests of verbal comprehension and artificial language are most valid for predicting success in the required cultural courses in the engineering curriculum. These tests have relatively low validities for predicting success in scientific or engineering subjects.

4. The spatial visualizing test is more valid than any other test for predicting success in pre-professional engineering subjects, *e.g.*, engineering drawing and descriptive drawing.

5. The test of mechanical ingenuity is of relatively little value for predicting success in any aspect of the freshman engineering curriculum.

6. The tests of mathematical aptitude and quantitative reasoning are most valid for predicting freshman grade point average. The mathematical aptitude test appears to be generally more valid than any other test in the battery. When scores on this test are properly combined with scores on the tests of quantitative reasoning, spatial visualizing, and verbal comprehension, the resultant validity closely approximates that yielded by the entire battery.

7. For purposes of predicting success in the freshman engineering curriculum, the validity of the Yale Aptitude Battery normally varies from .50 to .66. These validities compare favorably with the results obtained for other scholastic aptitude tests.

8. Further experimentations with batteries of tests designed to predict success in the freshman engineering curriculum should investigate tests of verbal ability, mathematical ability, and spatial visualizing ability and their relation to tests of other abilities not measured by the Yale Aptitude Battery.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS
OF ENGINEERING DRAWING
(Third of Four Issues)

WILLIAM E. STREET, *Editor*
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Course Outlines

Aims and objectives are vital in the evaluation of subject matter and logical sequence for the planning of course content in Engineering Drawing as well as other subjects. These have again been re-emphasized in our Army Specialized Training; Engineering, Science and Management War Training; Navy V–12 and other emergency programs.

Subject matter for each division or unit of a course should be thoughtfully planned and outlined in detail and this information made available to all teachers of a department at the beginning of a course. Where possible, every teacher should have a part in planning and outlining the material to be taught in a given subject. This familiarizes the young teachers with proved teaching methods and gives an opportunity to evaluate the ideas of each teacher. A good course outline should set forth essential information, such as, date, text assignment, home work problems, laboratory problems, drawing numbers, titles, required work, optional work, whether the work is to be done in pencil or ink, size of paper and cloths to be used, due date for each unit of work, values to be placed on each division of the work in determining the term or semester grades and regular scheduled examinations. When the teacher has this information available it is much easier to proceed with lesson plans for each day's work.

Furthermore, all teachers in a given department are covering the same material for each corresponding lesson and this results in uniformity in the amount of work required and makes for a well correlated program. It permits the use of substitute teachers during illness and other absences of the teacher with little or no interruption of the regular scheduled work. This type of program is challenging to the teacher to develop and present new ideas in his lecture-demonstrations which form a necessary part of any well-balanced Engineering Drawing course. It lends itself to working up and developing new problems for the examinations. It is advisable to have uniform examinations for each section of a given course meeting each period.

At the conclusion of each lesson if the teachers will annotate the work for that lesson it will be helpful in planning for the next terms work and provide a basis for revision of the course outline. These annotated course outlines can be discussed during departmental meetings resulting in a mutual benefit to all teachers and made available for use of the course outline committee in revising and bringing the course outlines up to date for the next terms work. A program of this kind will assist in the professional development of the entire teaching staff.

Teaching Engineering Drawing—A Profession

By JASPER GERARDI

Director Engineering Drawing, University of Detroit

At the Fiftieth Anniversary meeting of the S.P.E.E. held last June at Chicago, eight men were honored by the Society for their contribution to engineering education. This event of course, was of great interest to all but was of particular significance to teachers of engineering drawing because Professor Thomas E. French, recipient of the Lamme Award and Professor Frederick E. Giesecke who was awarded a certificate of charter membership in the Society, have devoted a considerable amount of their life's work to the teaching of Engineering Drawing.

What these men have contributed to engineering education by their excellent work and activities is known to all. More than this, they have placed and kept engineering drawing at a professional standard. In honoring these men the S.P.E.E. honors the teacher of drawing and it also seems to challenge the younger men to keep this subject on the established high level.

If the profession of teaching engineering drawing is to maintain its status, then much is yet to be done in the selection of teachers, course contents and proper teaching methods. The deficiencies which exist have only recently been exposed by the National Survey of Engineering Drawing conducted by Professor Hoelscher's committee. (Cf.: June 1943 issue S.P.E.E. Journal.) This report clearly shows that approximately 53% of all classes taught in the country are being taught by part-time teachers and student assistants. Although a certain amount of this can be tolerated, this percentage must drop. If we scrutinize the report more closely we find that approximately 35% of all the teachers have had a year or less of practical engineering experience. This situation is not critical, it does show, however, that there is a great deal of room for improvement. What this state of affairs will be by the end of the war is unpredictable, but it is certain that it will be much worse. Of course very little, if anything, can be done about it during this emergency.

As a post-war activity the S.P.E.E. and the E.C.P.D. ought not to allow these conditions to continue. Otherwise the result of the devoted efforts of men like Professors French and Giesecke to elevate the teaching of Engineering Drawing to a truly professional level will not endure.

Necrology

ELTON DAVID WALKER

Elton David Walker, Professor Emeritus of Civil Engineering, The Pennsylvania State College, died on February 24, 1944. He was born March 8, 1869 at Taunton, Massachusetts. After attending the public schools of Taunton he entered the Massachusetts Institute of Technology as a student of civil engineering and was graduated in 1890. After four years of engineering practice Professor Walker was appointed to the faculty of Union College. In 1900 he joined the faculty of The Pennsylvania State College with which he was connected continuously, except for a period of a leave of absence for military service during 1917 and 1918, until June 1939 when he retired. Professor Walker served successively as Assistant Professor and as Professor of Civil Engineering, and as head of that department. For many years he was an active and devoted member of the Society for the Promotion of Engineering Education. He served as lecturer on the teaching of public water supplies at the Civil Engineering Session of the Summer School for Engineering Teachers. Throughout the years of his service as a teacher Professor Walker also engaged in consulting engineering practice, particularly in sanitary engineering, and engaged in research activities and the publication of articles and monographs related to his research undertakings.

Professor Walker rendered military service of conspicuous value during the first World War. He went over seas in July 1917 as Captain in the 15th Engineers. In France he was engaged in various lines of construction work on railroads, water supply and drainage systems, warehouses, hospitals, barracks, and other structures. He was awarded the decoration of the Purple Heart and a citation by General Pershing "for exceptionally meritorious and conspicuous services with the 15th Railway Engineers at Jonchery and Liffol-le-Grand." Professor Walker continued his interest in military matters after the close of the war, and was commissioned Lieutenant Colonel in the Engineer Section of the Officers Reserve Corps.

Professor Walker was a member of many professional societies, including the American Society of Civil Engineers, the American Water Works Association, New England Water Works Association, the American Association of University Professors, Society of American Military Engineers, as well as the Society for the Promotion of Engineering Education. He was a member of Sigma Xi, Phi Kappa Phi, Tau Beta Pi, and Delta Kappa Epsilon.

Sections and Branches

The **University of Iowa** is again offering a three-week Management Course from June 12 to 30, 1944. This course is designed primarily for people from industry who want comprehensive training in Production Planning, Plant Layout, Motion and Time Study, Wage Incentives, and related subjects, and combines fundamental training with practical applications.

E.S.M.W.T. instructors as well as those people in industry responsible for reducing manufacturing costs and increasing production will find this course of especial benefit. Attention will also be given to procedures to be followed in conducting factory training programs in this field.

A regular meeting of the **Michigan College of Mining and Technology Branch** of the S.P.E.E. was held March 7, 1944. Members and guests heard two interesting and instructive speeches. Guests included representatives of the College Board of Control and also school superintendents and principals.

James Fisher, dean of the faculty and head of the department of mathematics and physics, spoke on "The Relation of the Engineers' Council for Professional Development to the S.P.E.E." He discussed the origin, aims and accomplishments of the Council and its relationship to the engineering societies. He paid tribute to a distinguished M.C.M.T. alumnus, Brigadier General Robert I. Rees, who before his death in 1936 had been very active in the Council as well as in the S.P.E.E. Dr. Fisher also discussed the functions of the several committees of the E.C.P.D.

G. M. Machwart of the chemical engineering department described "Research Problems in Chemistry and Chemical Engineering at M.C.M.T." He outlined the purposes, scope, and importance of the departmental research program and pointed out the necessary stages leading to the establishment of new local industries.

Following the speeches came a period of questions and discussion. The meeting then adjourned so that members and guests could inspect the laboratories of the chemistry and chemical engineering departments.

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